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FOR
TESTING MATERIALS

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PROCEEDINGS
OF THE
TWENTY-SECOND ANNUAL MEETING

Held at Atlantic City, New Jersey
June 24-27, 1919

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TENTATIVE STANDARDS

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SUMMARY OF THE PROCEEDINGS OF THE TWENTY-SECOND ANNUAL MEETING.

ATLANTIC CITY, N. J., JUNE 24–27, 1919.

THE TWENTY-SECOND ANNUAL MEETING OF THE AMERICAN SOCIETY FOR TESTING MATERIALS was held at the Hotel Traymore, Atlantic City, N. J., June 24–27, 1919. The following is an analysis of attendance at the meeting: Members in attendance or represented, 560; guests, 133; total, 693; ladies, 174. The corresponding statistics for the Twenty-first Annual Meeting are: Members in attendance or represented, 474; guests, 129; total, 603; ladies, 108.

The names of the members who were present or represented are given in Appendix I to this Summary.

FIRST SESSION—TUESDAY, JUNE 24, 10 A. M.

President G. H. Clamer in the chair.

The minutes of the Twenty-first Annual Meeting were approved as printed.

The President appointed Mr. G. L. Norris and Mr. G. C. Stone as tellers to canvass the vote for officers.

The Assistant Secretary presented the annual report of the Executive Committee.

The Assistant Secretary moved on behalf of the Executive Committee that the following amendment to Article I, Section 3, of the By-laws be referred to letter ballot for adoption, calling attention to the fact that the proposed amendment does not apply to present Junior Members of the Society:

Amend Section 3 to read as follows, by omitting the words in brackets and adding the words in italics:

> "A Junior Member shall be a person less than [thirty] *twenty-seven* years of age on the date of his admission, proposed by two members and elected by the Executive Committee.

> "A Junior Member shall have the same rights and privileges as a Member, except that he shall not be eligible for office, and his status shall be changed from that of Junior Member to Member at the beginning of the fiscal year next succeeding the date on which he attains the age of [thirty] *twenty-seven* years; *provided that a Junior Member holding membership at the date of adoption of this Section shall be continued under that status until the beginning of the fiscal year next succeeding the date on which he attains the age of thirty years.*"

This motion was unanimously carried.

The Assistant Secretary then moved on behalf of the Executive Committee that the following amendment to Article II, Section 5, of the By-laws be referred to letter ballot for adoption:

Amend the first sentence of Section 5 as follows, by omitting the words in brackets and adding the words in italics:

"The Secretary-Treasurer shall be elected annually by the Executive Committee at the first [meeting following the announcement of elections.] *quarterly meeting following the Annual Meeting of the Society.*"

This motion was unanimously carried.

The President explained that Mr. M. O. Leighton, Chairman of the National Service Committee of Engineering Council, who was to have addressed the Society on the activities of that Committee, had found in impossible to attend the meeting, and requested Mr. G. Aertsen to read a statement which Mr. Leighton had prepared. Mr. Aertsen then read this statement, which may be summarized briefly as follows:

> The functions of the office of Engineering Council in Washington are two-fold: "First, it is the office of the Washington representative of Engineering Council; and second, as the Washington representative is also Chairman of the National Service Committee, the office becomes the headquarters of that Committee. The underlying thought in the establishment of the Washington office is service, both to the nation and to the engineer."
>
> "Service to the Nation so far consists of rendering

> advice and assistance in engineering matters, on the initiative of either party. It is the ambition of the Engineering Council to so demonstrate its usefulness and merit among the executives and legislators in Washington that it will become an established practice to refer engineering matters of the Government to Council and thence to the member societies."
>
> Reference was then made to the following services which the National Service Committee can render to the engineers of the country:
>
> "The critical examination of all bills and resolutions introduced into Congress concerning engineering matters of whatsoever kind, and the issuance of bulletins thereon for the purpose of keeping the engineers of the country informed concerning the status and progress of engineering legislation."
>
> "Another avenue of assistance is represented by what we have called the Legislative and Departmental Information and Service. It is well known that the Government has for many years been carrying on engineering research and, during the last ten years especially, has gathered a large amount of engineering data. Any engineer may, by applying to the National Service Committee, secure all available information in the various departments concerning any engineering subject."
>
> Among the most important activities of the National Service Committee is the movement to secure the establishment of a National Department of Public Works, the result of which has been thoroughly described in the technical press of the country.

The report of Committee E-6 on Papers and Publications was presented by its chairman, Mr. C. L. Warwick. The recommendation of the committee that the requirement of the Regulations Governing Standing Committees, that committee reports be mailed four weeks in advance of the annual meeting, be waived in the case of the five reports which had not been thus mailed—Committees C-1 on Cement, C-2 on Reinforced Concrete, C-7 on Lime, C-11 on Gypsum and D-11 on Rubber Products—was, on motion of Mr. Warwick, approved.

The report of Committee D-3 on Methods of Sampling and Analysis of Coal, Mr. S. W. Parr, chairman, was, in the absence of the chairman, presented by Mr. S. S. Voorhees, a member of the committee. Mr. Voorhees called on Mr. A. C. Fieldner to present the proposed Tentative Method for Determination of Fusibility of Coal Ash. On motion of Mr. Fieldner, this Method was accepted for publication as a tentative standard of the Society.

The report of Committee E-4 on Magnification Scales for Micrographs was presented by the Assistant Secretary, in the absence of Mr. W. H. Bassett, chairman. The proposed revisions in the Tentative Definitions and Rules Governing the Preparation of Micrographs of Metals and Alloys (E 2–18 T) were, on motion of the Assistant Secretary, approved and the Definitions and Rules as amended continued as tentative.

The President then invited Mr. H. E. Howe, Vice-Chairman of the Division of Industrial Relations of the National Research Council, to say a few words in connection with the work of that Division.

> After referring to the fact that the Society is officially represented on the Engineering Division of the National Research Council, Mr. Howe pointed out that while the National Research Council has the full support of the Government, it is not a Government body, but is working with a private endowment in the endeavor to further research in this country. He stated that in England a plan has been adopted of forming cooperative research associations principally among the producers of various kinds of materials. In this country it is proposed to follow a somewhat different plan, namely, the coördination of existing research facilities in the form of associations to undertake various research problems, in which manufacturers and consumers in the various industries will work in cooperation. While it is realized that much important work is being done by certain groups, it is felt that much of the fundamental research which needs to be done is of such a broad type that no one organization could profitably undertake it, and do it as it should be done for the benefit of all the industries. When the details have been worked out, the Research Council hopes to have a plan which not only the Society and its membership individually can fully approve, but to which those who are interested in such research can give both moral and material support. The first research association will have to do with alloys.

The tellers on the votes for election of officers presented their report, and in accordance therewith the President announced the election of the following officers:

For President, to serve for one year: J. A. Capp.

For Vice-President, to serve for two years: C. D. Young.

For Members of the Executive Committee, to serve for two years: Ernest Ashton, H. F. Moore, C. F. W. Rys, Admiral D. W. Taylor.

The President asked Past-Presidents Mansfield Merriman and A. A. Stevenson to escort the President-elect to the chair. Mr. Capp expressed his appreciation of the honor conferred upon him by election to the presidency of the Society, and in pledging himself to fulfill the responsibilities of his office, asked for the continued hearty cooperation of the members.

The meeting then adjourned till 3 P. M.

SECOND SESSION—TUESDAY, JUNE 24, 3 P. M.

On Preservative Coatings, Lubricants and Containers.

President G. H. Clamer in the chair.

On invitation of the President, Mr. E. H. Walker, President of the Railway Supply Manufacturers' Association, extended a cordial invitation to the members of the Society to visit the exhibit on Young's Million Dollar Pier of railway materials, shop tools, machinery, etc., conducted under the auspices of the Railway Supply Manufacturers' Association and the American Railway Association, Mechanical Section.

On invitation of the President, Mr. G. B. Heckel then assumed the chair.

The report of Committee D-1 on Preservative Coatings for Structural Materials was presented by its chairman, Mr. P. H. Walker. On motion of Mr. Walker, the Tentative Test for Flash Point of Volatile Paint Thinners (D 28–18 T), with the amendments recommended by the committee, was referred to letter ballot of the Society for adoption as standard.

A paper entitled, "Paint, a Plastic Material and not a Viscous Liquid: The Measurement of Its Mobility and Yield Value," by Mr. E. C. Bingham and Mr. Henry Green, was presented by Mr. Green and discussed.

The report of Committee D-2 on Lubricants was then presented by its chairman, Mr. C. P. Van Gundy, and discussed. On motion of Mr. Van Gundy, the proposed Tentative Test for Viscosity of Lubricants was accepted for publication as a tentative standard of the Society.

A paper on "A Viscosimeter for Gasoline" was presented by its author, Mr. Winslow H. Herschel.

The report of Committee D-10 on Shipping Containers was presented by Mr. J. A. Newlin, the chairman, and discussed.

The meeting then adjourned till 8 P. M.

THIRD SESSION—TUESDAY, JUNE 24, 8 P. M.

Presidential Address and Memorial Session.

Past-President A. A. Stevenson in the chair.

On invitation of the chair, President G. H. Clamer read the Presidential Address entitled "Standardization."

The chair then announced that the Memorial Session in honor of Dr. Edgar Marburg, late Secretary-Treasurer of the American Society for Testing Materials, would now be held; and, on his invitation, President Clamer opened the Session with a brief address on behalf of the Executive Committee of the Society, concluding with the resolution which had been adopted in October, 1918, by the Executive Committee. During Mr. Clamer's remarks there was unveiled an oil portrait of Dr. Marburg which had been presented to the University of Pennsylvania by its Engineering Alumni.

A letter was then read from Dr. Edgar F. Smith, Provost of the University of Pennsylvania, expressing his sincere regret at being unable to attend the Memorial Session to speak on Doctor Marburg's activities as a teacher.

The following addresses, covering the life and life-work of Doctor Marburg, were then presented:

"As an Engineer," by John M. Goodell;
"Early Activities in the Society," by Robert W. Lesley;
"More Recent Service in the Society," by Arthur N. Talbot;
"A Personal Tribute," by Robert W. Hunt.

The chair then closed the Memorial Session with a brief tribute to Doctor Marburg, the meeting rising in silent tribute to his memory.

The chair then announced that the Executive Committee at its quarterly meeting in April had elected the Assistant Secretary of the Society, Mr. C. L. Warwick, as Secretary-Treasurer, his term of office to begin at the close of the Memorial Session, and introduced him as such to the meeting. Mr. Warwick expressed his appreciation of the honor thus conferred upon him, acknowledged his great indebtedness to the guidance and help that Doctor Marburg had ever extended to him, and pledged his best endeavors to meet the responsibilities which had been entrusted to him by the Executive Committee.

On invitation of the chair, President Clamer announced that the Executive Committee had voted unanimously to confer the distinction of honorary membership upon three of its Past-Presidents: Prof. Mansfield Merriman, Dr. Henry M. Howe and Capt. Robert W. Hunt. This announcement was greeted with applause, to which Professor Merriman and Captain Hunt responded. Doctor Howe, who was in Europe, was advised of this honor by cablegram.

The meeting then adjourned till the following morning.

FOURTH SESSION—WEDNESDAY, JUNE 25, 10 A. M.

On Steel and Wrought Iron.

On the invitation of President Clamer, Past-President Robert W. Hunt, Honorary Member of the Society, assumed the chair.

The report of Committee A-1 on Steel was presented by its chairman, Mr. J. A. Capp. On motion of Mr. Capp, the proposed revisions in Standard Specifications for Open-hearth Steel Girder and High Tee Rails (A 2–12) were accepted for publication as tentative.

On further motion of Mr. Capp, the proposed Tentative Specifications for Plates for Forge Welding, were accepted for publication as a tentative standard of the Society.

Mr. Capp then submitted the recommendations of the committee with respect to the disposition of the following note which had been added to 43 specifications of the Society at the last annual meeting:

> "In view of the abnormal difficulty in obtaining materials in time of war, the rejection limits for sulfur in all steels and for phosphorus in acid steels shall be raised 0.01 per cent above the values given in these specifications. This shall be effective during the period of the war and until otherwise ordered by the Society."

After referring to the statement in the report of the committee concerning the committee's consideration of this question during the year, Mr. Capp stated that a meeting of the committee had been held Monday afternoon, June 23, at which had been received the report of a special committee appointed to canvass the entire situation. After very careful consideration, the committee desired to recommend to the Society that the 43 specifications to which this note has applied be divided into two classes: (1) Those specifications from which the note is to be removed at the present annual meeting, as of July 1, 1919; (2) Those specifications from which the note is not to be removed at this time, and consideration of its removal is to be deferred until the annual meeting in 1920. In pursuance of this action of the committee, Mr. Capp moved that the note be removed, as of July 1, 1919, from the following 29 specifications:

NOTE REMOVED AS OF JULY 1, 1919.

Standard Specifications for:

Open-hearth Steel Girder and High Tee Rails (A 2–12);
Medium-Carbon Steel Splice Bars (A 4–14);
High-Carbon-Steel Splice Bars (A 5–14);
Extra-High-Carbon Steel Splice Bars (A 6–14);
Quenched High-Carbon-Steel Splice Bars (A 49–15);
Quenched Carbon-Steel Track Bolts (A 50–16);
Quenched Alloy-Steel Track Bolts (A 51–16);
Structural Steel for Bridges (A 7–16);
Structural Nickel Steel (A 8–16);
Carbon-Steel Bars for Railway Springs (A 14–16);
Carbon-Steel Bars for Vehicle and Automobile Springs (A 58–16);

Silico-Manganese-Steel Bars for Automobile and Railway Springs (A 59–16);
Chrome-Vanadium-Steel Bars for Automobile and Railway Springs (A 60–16);
Carbon-Steel Bars for Railway Springs (A 68–18);
Carbon-Steel and Alloy-Steel Blooms, Billets and Slabs for Forgings (A 17–18);
Carbon-Steel and Alloy-Steel Forgings (A 18–18);
Quenched-and-Tempered Carbon-Steel Axles, Shafts, and Other Forgings for Locomotives and Cars (A 19–18);
Carbon-Steel Forgings for Locomotives (A 20–16);
Carbon-Steel Car and Tender Axles (A 21–18);
Cold-Rolled Steel Axles (A 22–16);
Quenched-and-Tempered Alloy-Steel Axles, Shafts, and Other Forgings for Locomotives and Cars (A 63–18);
Wrought Solid Carbon-Steel Wheels for Steam Railway Service (A 57–16);
Wrought Solid Carbon-Steel Wheels for Electric Railway Service (A 25–16);
Steel Tires (A 26–16);
Automobile Carbon and Alloy Steels (A 29–18);
Cold-Drawn Bessemer Steel Automatic Screw Stock (A 32–14);
Cold-Drawn Open-hearth Steel Automatic Screw Stock (A 54–15).

Tentative Specifications for:

Boiler and Firebox Steel for Stationary Service (A 70–18 T);
Carbon Tool Steel (A 71–17 T).

This motion was unanimously carried.

Mr. Capp then moved that consideration of the removal of the note from the 14 remaining specifications to which it applies be deferred until the annual meeting in 1920. These specifications are as follows:

CONSIDERATION OF REMOVAL OF NOTE DEFERRED TILL 1920.

Standard Specifications for:

Carbon-Steel Rails (A 1–14);
Low-Carbon-Steel Splice Bars (A 3–14);
Structural Steel for Buildings (A 9–16);
Structural Steel for Locomotives (A 10–16);

Structural Steel for Cars (A 11–16);
Structural Steel for Ships (A 12–16);
Rivet Steel for Ships (A 13–14);
Billet-Steel Concrete Reinforcement Bars (A 15–14);
Steel Castings (A 27–16);
Lap-Welded and Seamless Steel Boiler Tubes for Locomotives (A 28–18);
Lap-Welded and Seamless Steel and Wrought-Iron Boiler Tubes for Stationary Service (A 52–18);
Iron and Steel Chain (A 56–18).

Tentative Specifications for:

Steel Tie Plates (A [illegible]–18 T);
Low-Carbon-Steel Track Bolts (A 76–18 T).

This motion was unanimously carried.

Mr. Capp stated that Committee A-1 has under consideration the creation of a special committee to make a study of the influence of sulfur and phosphorus in steel, and to determine whether the phosphorus and sulfur limits in the A.S.T.M. steel specifications are proper ones. In this study it is hoped that the cooperation of the United States Railroad Administration and the Bureau of Standards may be secured.

Mr. Capp then stated that at the meeting of the committee on Monday, there had been presented a proposed revision in Section 10 on Workmanship in the Tentative Specifications for Low-Carbon-Steel Track Bolts (A 76–18 T) and a proposed revision in Table IV on Automobile Chromium Steels in the Standard Specifications for Automobile Carbon and Alloy Steels (A 29–18). Since these revisions had been received too late for submission to letter ballot of the committee, Mr. Capp moved that the committee be permitted to include them in its report for information only.[1] This motion was carried.

The report of Committee A-2 on Wrought Iron was then introduced by its chairman, Mr. H. E. Smith. On motion of Mr. Smith, the proposed revision in the Standard Specifications for Engine-Bolt Iron (A 40–18) was accepted for publication as tentative.

The proposed Tentative Specifications for Extra-Refined

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[1] The revisions in these two specifications appear in full in the Addendum to the Report of Committee A-1, p. 171.

Wrought-Iron Bars were on motion of Mr. Smith accepted for publication as a tentative standard of the Society.

Mr. Smith stated that at the request of Committee A-1, Committee A-2 had held a short meeting on Monday afternoon, to consider the disposition of the Phosphorus and Sulfur Note which appears on the Standard Specifications for Iron and Steel Chain (A 56–18), and that the committee had recommended to Committee A-1 that this note should be retained.[1]

A paper on "Deep Etching of Rails and Forgings," by Mr. F. M. Waring and Mr. K. E. Hofammann, was then presented by Mr. Waring, and discussed.

In the absence of its author, Mr. John A. Mathews, the Secretary-Treasurer presented a paper entitled "Modern High Speed Steel," which was then discussed.

A paper entitled "Some Fatigue Tests of Nickel Steel and Chrome-Nickel Steel," by Mr. H. F. Moore and Mr. Arthur G. Gehrig, was read by Mr. Moore, and discussed.

A motion picture illustrating the box-testing work at the U. S. Forest Products Laboratory was presented by Mr. J. A. Newlin.

The meeting then adjourned till 8 P. M.

FIFTH SESSION—WEDNESDAY, JUNE 25, 8 P. M.

On Corrosion and Magnetic Analysis.

President-elect J. A. Capp in the chair.

The report of Committee A-5 on Corrosion of Iron and Steel was presented by its chairman, Mr. S. S. Voorhees. He then called on Mr. H. E. Smith to present the report of Sub-Committee III on Inspection of the Fort Sheridan, Pittsburgh and Annapolis Tests.

Discussion of the report of the committee was deferred while Mr. D. M. Buck presented his paper on "The Influence of Very Low Percentages of Copper in Retarding the Corrosion of Steel." The report of the committee and Mr. Buck's paper were then discussed jointly.

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[1] This specification is included in the list of specifications on which consideration of the removal of the note has been deferred until 1920; see p. 18.

A topical discussion on "Magnetic Analysis" was then introduced by the presentation of the following five papers:

"Magnetic Analysis as a Criterion of the Quality of Steel and Steel Products," by Mr. Charles W. Burrows and Mr. Frank P. Fahy; presented by Mr. Burrows.

"Magnetic Surveys on New and Failed Rails," by Mr. P. H. Dudley; presented by Mr. C. B. Bronson.

"Application of Magnetic Analysis to the Testing of Ball Bearing Races," by Mr. R. L. Sanford and Mr. M. F. Fischer; presented by Mr. Sanford.

"Location of Flaws in Rifle-Barrel Steel by Magnetic Analysis," by Mr. R. L. Sanford and Mr. W. B. Kouwenhoven; presented by Mr. Kouwenhoven.

"Certain Aspects of Magnetic Analysis," by C. Nusbaum.

After the presentation of written discussions, the subject was opened for general discussion.

The meeting then adjourned till the following morning.

SIXTH SESSION—THURSDAY, JUNE 26, 10 A. M.

On Testing and Apparatus; Rubber Products and Textiles.

President G. H. Clamer in the chair.

The Secretary-Treasurer stated that the Executive Committee, in pursuance of the announcement in its annual report, had given careful consideration to the proposed reorganization of the American Engineering Standards Committee, at its meeting held Wednesday afternoon, June 25. He reviewed briefly the history of this movement, and then stated that the Executive Committee after very careful discussion found itself unable to approve of the proposed reorganization. It had accordingly adopted the following motion:

> "That it is the sense of the Executive Committee that the proposed change in the Constitution of the American Engineering Standards Committee is not looked upon with

favor at this time, and that a committee be appointed by the chair to confer with the other member bodies to get their views and report at the October meeting."

The Secretary-Treasurer also made the announcement, on behalf of the Executive Committee, that it seemed now practically certain that an agreement can be reached with the Engineers' Club of Philadelphia, by which very suitable Society headquarters would be established at 1315 Spruce Street.

On invitation of the President, Mr. H. F. Moore then assumed the chair.

The report of Committee E-1 on Methods of Testing, Mr. G. Lanza, chairman, was presented by the secretary, Mr. S. V. Hunnings. Mr. Hunnings explained that it had not been possible to put in type an appendix to the report entitled "Standardization of Methods for the Determination of Density," by Mr. H. W. Bearce. On motion of Mr. Hunnings, it was voted to accept the report, including the appendix, for publication in the Proceedings.

A paper describing a "Wire Testing Extensometer," by Mr. T. D. Lynch and Mr. P. H. Brace, was presented by Mr. Brace, and discussed.

A paper entitled "Development of Brinell Hardness Tests of Thin Brass Sheet," by Capt. S. L. Goodale and Mr. R. M. Banks, was presented by Captain Goodale.

In the absence of the author, Mr. H. L. Whittemore presented a paper on a "Fatigue Testing Machine," by Mr. F. M. Farmer.

Following the discussion of this paper, a paper entitled "The Single Blow Notched Bar Impact Test as Used in the American Industry" was read by its author, Mr. E. H. Dix, Jr.

The report of Committee D-11 on Rubber Products was then presented by its chairman, Mr. E. A. Barrier. On motion of Mr. Barrier, the proposed Tentative Specifictions for Leader Hose for Use with Pneumatic Tools were accepted for publication as a tentative standard of the Society.

On motion of Mr. Barrier, the revisions in Tentative Specifications for Rubber Belting for Power Transmission (D 53–18 T) recommended by the committee were accepted and the specifications continued as tentative.

The recommendation of the committee that certain revisions in the Standard Specifications for $2\frac{5}{8}$-in. Cotton Rubber-Lined Fire Hose for Private Department Use (D 14–15) and for $2\frac{1}{2}$, 3 and $3\frac{1}{2}$-in. Double-Jacketed Cotton Rubber-Lined Fire Hose for Public Fire Department Use (D 26–18) be published as tentative was, on motion of Mr. Barrier, approved.

Mr. Barrier then moved that the proposed Tentative Specifications for Adhesive Insulating Tape, be accepted for publication as a tentative standard of the Society.

The Secretary-Treasurer called attention to the fact that since these specifications deal with insulating materials and contain a test for dielectric strength, it would be inadvisable to publish them even as tentative without having the committee first consult with Committee D-9 on Electrical Insulating Materials and Committee E-2 on Electrical Standards, the latter committee having been appointed for the purpose of cooperating with the American Institute of Electrical Engineers in any matter of standards which concern the two societies. The Secretary-Treasurer accordingly moved an amendment to the original motion that these specifications be referred back to Committee D-11, and that the committee be directed to consult with Committees D-9 and E-2. This amendment was seconded and, after some discussion, adopted. The original motion as thus amended was then adopted.

A paper entitled "Steam Hose" was then presented by its author, Mr. H. J. Force.

The report of Committee D-13 on Textile Materials, Mr. G. B. Haven, chairman, was in the absence of the chairman presented by Mr. D. E. Douty, the secretary. Following the presentation of the printed report, Mr. Douty recommended on behalf of the committee that certain minor modifications be made in the Tentative General Methods for Testing Cotton Fabrics (D 39–18 T) as follows: In Table I, on "Tensile Strength Test Methods," change the words in the first column "Speed of separation of jaws, in. per min." to read "Speed of pulling jaw, in. per min." Also under "Method No. 4, Single Strand," change the speed of pulling jaw from 20 to 12 in. per minute.

Mr. Douty explained that these proposed revisions would be submitted to a letter ballot vote of the committee, and on his motion the revisions were approved, provided the vote of the committee was favorable.

The meeting then adjourned till 8 P. M.

SEVENTH SESSION—THURSDAY, JUNE 26, 8 P. M.

On Malleable Iron and Non-Ferrous Metals.

President G. H. Clamer in the chair.

The report of Committee A-7 on Malleable Castings was presented by its chairman, Mr. H. E. Diller. Mr. Diller moved that the recommendation of the committee that the Tentative Specifications for Malleable Castings (A 75–18 T) be referred to letter ballot of the Society for adoption as standard be approved, with the understanding that if adopted they would supersede the present Standard Specifications for Malleable-Iron Castings (A 47–15). An amendment by Mr. G. Aertsen that the serial designation of the tentative specifications, if thus adopted, be changed to A 47 to agree with the designation of the standard to be replaced, was accepted by Mr. Diller and the motion as thus amended was carried.

A paper entitled "Some Physical Constants of Malleable Cast Iron" was presented by its author, Mr. H. A. Schwartz, and discussed. A suggestion from Mr. G. B. Waterhouse that the title of the paper might well be amended so that it is clear that the data presented apply to American malleable iron was referred to the author for his consideration.

The chair then called for the report of the Golf Tournament Committee, Mr. E. D. Boyer, chairman. Mr. Boyer stated that a very successful tournament had been held that afternoon in spite of unfavorable weather conditions, and awarded the following prizes as a result:

For Low Score for the Course:

The American Society for Testing Materials Championship Cup and medal: Mr. Robert E. Griffith, Philadelphia, Pa.

For the Lowest Net Score:

First Prize..........Mr. W. M. Kinney, Chicago, Ill.
Second Prize.........Mr. W. D. Lober, Philadelphia, Pa.
Third Prize..........Mr. G. D. White, Newark, N. J.

For the winner of the "Blind Handicap:"

A silver cup..........Mr. A. S. Hook, Chicago, Ill.

The report of Committee B-1 on Copper Wire was then presented by Mr. J. A. Capp, chairman. On motion of Mr. Capp, the proposed Tentative Specifications for Tinned Soft or Annealed Copper Wire for Rubber Insulation were accepted for publication as a tentative standard of the Society.

The report of Committee B-2 on Non-Ferrous Metals and Alloys, Mr. Wm. Campbell, chairman, was in his absence presented by Mr. W. M. Corse, one of the vice-chairmen of the committee. On successive motions of Mr. Corse, the following action was taken with respect to the various recommendations in the report of the committee:

The proposed Tentative Specifications for Lead were accepted for publication as a tentative standard of the Society, provided a subsequent letter ballot vote of the committee should be favorable, it having been explained that there had not been opportunity for such a vote prior to the presentation of the specifications.

The following three specifications were referred to letter ballot vote of the Society for adoption as standard:

Tentative Specifications for Cartridge Brass (B 19–18 T);
Tentative Specifications for Cartridge Brass Disks (B 20–18 T);
Tentative Specifications for Naval Brass Rods for Structural Purposes (B 21–18 T).

The proposed Tentative Specifications for Brass Ingot Metal for Sand Castings were accepted for publication as a tentative standard of the Society, with the following amendment recommended by the committee: In Section 4 on "Permissible Variations," third line of the table, change the words "Over 10 to 40 per cent, incl." to read "Over 10 per cent"; and omit the last line of the table.

The proposed Tentative Specifications for Bronze Bearing Metal in Ingot Form were accepted for publication as a tentative standard of the Society, with the following revisions recommended by the committee: (1) In Section 3 on "Chemical Composition" change the maximum per cent of iron in alloy grade No. 3 from 0.40 to 0.25; (2) In Section 4 on "Permissible Variations," third line of the table, change the words "Over 10 to 30 per cent, incl." to read "Over 10 per cent"; and omit the last line of the table.

The proposed Tentative Specifications for Solder Metal were accepted for publication as a tentative standard of the Society.

The Tentative Methods for Chemical Analysis of Manganese Bronze (B 27–18 T) and the Tentative Methods for Chemical Analysis of Gun Metal (B 28–18 T) were referred to letter ballot of the Society for adoption as standard.

The proposed Tentative Methods for Battery Assay of Copper and the proposed Tentative Methods for Chemical Analysis of Pig Lead were accepted for publication as tentative standards of the Society.

The slight revisions recommended by the committee in the following tentative specifications were approved, and the specifications continued as tentative:

Tentative Specifications for Aluminum Ingots for Remelting and for Rolling (B 24–18 T);
Tentative Specifications for Aluminum Sheet (B 25–18 T);
Tentative Specifications for Light Aluminum Casting Alloys (B 26–18 T).

A paper entitled "The Behavior of Wrought Manganese Bronze Exposed to Corrosion While Under Tensile Stress," by Mr. P. D. Merica and Mr. R. W. Woodward, was presented by Mr. Woodward, and discussed.

A paper entitled "Some Tests of Light Aluminum Casting Alloys: The Effect of Heat Treatment," by Mr. P. D. Merica and Mr. C. P. Karr, was then presented by Mr. Merica.

The meeting then adjourned till the following morning.

EIGHTH SESSION—FRIDAY, JUNE 27, 10 A. M.

On Ceramics, Lime and Road Materials.

On invitation of President G. H. Clamer, Past-President A. N. Talbot assumed the chair.

The report of Committee C-3 on Brick, Mr. Edward Orton, Jr., chairman, was, in the absence of the chairman, presented by Mr. A. V. Bleininger, secretary. On motion of Mr. Bleininger, the proposed Tentative Specifications for Building Brick were accepted for publication as a tentative standard of the Society.

Mr. Bleininger then outlined briefly a report entitled "A Study of the Proposed A.S.T.M. Specifications for Building Brick and a Correlation of Their Requirements with Sodium-Sulfate Treatment and Actual Freezing," by Mr. Orton, which is designed as an appendix to the report of the committee, but which it was found impossible to preprint for the meeting. On motion of Mr. Bleininger this report was accepted for publication.

The report of Committee C-6 on Drain Tile was presented by its chairman, Mr. A. Marston.

The report of Committee C-8 on Refractories was then presented by its chairman, Mr. A. V. Bleininger. On motion of Mr. Bleininger, the proposed Tentative Test for Determination of Softening Point of Fire-Clay Brick was accepted for publication as a tentative standard of the Society.

Mr. Bleininger then presented the recommendation of the committee that the present Tentative Test for Slagging Action of Refractory Materials (C 17–17 T) be superseded by the proposed revised Tentative Test appended to the report of the committee. He called attention to a typographical error in footnote No. 4 of the Test, and recommended further that the first sentence in Section 4 on "Measuring the Penetration" be changed to read as follows: "When cold, the brick shall be sawed so that one of the sawed surfaces accurately bisects the center of the rings; but it will be permissible to nick and break the bricks provided they are broken so that there is no greater variation than $\frac{3}{16}$ in. from either side of a straight line through the center of the rings." On motion of Mr. Bleininger, the proposed revised Test as thus amended was accepted for publication as tentative, to replace the present Test.

The proposed Tentative Definitions of Clay Refractories were on motion of Mr. Bleininger accepted for publication as a tentative standard of the Society.

A paper entitled "Preventable Defects in Refractory Bricks," by Mr. C. E. Nesbitt and Mr. M. L. Bell, was presented by Mr. Nesbitt, and discussed.

Chairman Talbot was obliged to leave the meeting at this point, and President Clamer assumed the chair.

The report of Committee C-7 on Lime was presented by its chairman, Mr. D. K. Boyd. On motion of Mr. Boyd, the revision in the requirements for fineness in the Tentative Specifications for Masons' Hydrated Lime (C 6–17 T) recommended by the committee were approved and the specifications continued as tentative.

The proposed Tentative Methods for Chemical Analysis of Limestone, Lime and Hydrated Lime were on recommendation of the committee revised by omitting from the second paragraph of the specifications the words "(if the sum of the SiO_2, Al_2O_3, and Fe_2O_3 is more than 5 per cent) or 2 g. (if the sum of the SiO_2, Al_2O_3 and Fe_2O_3 is less than 5 per cent)." On motion of Mr. Boyd, these Methods as thus amended were accepted for publication as a tentative standard of the Society.

The report of the committee proposed a definition of "Plasticity," with the request that it be considered by other committees of the Society concerned with this property of materials. The report also contained a resolution referred to the Executive Committee of the Society, and a suggestion of the desirability of the adoption by the Society of the standard testing sieves promulgated by the Bureau of Standards. The report of the committee was accepted with the understanding that the definition of "Plasticity" would be referred to other committees as requested, and that the Executive Committee of the Society would consider the resolution referred to it, as well as the suggestion relative to the adoption of standard testing sieves.

The report of Committee D-4 on Road Materials was then presented by its chairman, Mr. A. H. Blanchard. On motion of Mr. Blanchard, the recommendation of the committee that the Tentative Tests for Determination of Apparent Specific Gravity of Sand, Stone, and Slag Screenings and Other Fine Non-Bituminous Highway Materials (D 55–18 T) be referred to letter ballot of the Society for adoption as standard, was approved.

Mr. Blanchard moved that the Tentative Method for Determination of Softening Point of Bituminous Materials other than Tar Products (D 36–16 T), revised as recommended by the committee in its report, be referred to letter ballot of the Society for adoption as standard. This motion was adopted.

The revision recommended by the committee in the Standard Test for Loss on Heating of Oil and Asphaltic Compounds (D 6–16) was on motion accepted for publication as tentative.

The following methods and specifications were then, on motion of Mr. Blanchard, accepted for publication as tentative standards of the Society:

Proposed Tentative Method for Determination of Softening Point of Tar Products (Cube in Water Method);

Proposed Tentative Specifications for Materials for Cement Grout Filler for Brick, Stone Block and Wood Block Pavement, the title to be changed to read, on the recommendation of the committee, "Specifications for Materials for Cement Grout Filler for Brick and Stone Block Pavement";

Proposed Tentative Specifications for Materials for Cement Mortar Bed for Brick, Stone Block and Wood Block Pavement;

Proposed Tentative Specifications for Block for Granite Block Pavement.

A paper entitled "Apparatus for Determination of Breaking Point of Pitches," by Mr. H. E. Lloyd and Mr. P. P. Sharples, was read by Mr. Sharples, and discussed.

The meeting then adjourned till 3 P. M.

NINTH SESSION—FRIDAY, JUNE 27, 3 P. M.

On Concrete and Gypsum.

On invitation of President G. H. Clamer, Vice-President George S. Webster assumed the chair.

The report of Committee C-2 on Reinforced Concrete was then read by its chairman, Mr. Richard L. Humphrey.

Mr. Rudolph Hering, chairman, then presented the report of Committee C-4 on Clay and Cement Sewer Pipe. On motion of Mr. Hering, the Tentative Recommended Practice for Laying Sewer Pipe (C 12–17 T) was referred to letter ballot of the Society for adoption as Recommended Practice.

Mr. Hering then submitted an addendum to the report with the statement that it had been approved at a meeting of the committee held during the annual meeting, but that there had not been opportunity to refer it to a letter ballot vote of the committee. The appendix contained proposed revisions in the Tentative Specifications for Cement-Concrete Sewer Pipe (C 14–18 T).[1] On motion of Mr. Hering, these revisions were approved and the specifications continued as tentative, subject to a favorable vote by letter ballot of the committee.

The report of Committee C-11 on Gypsum, Mr. R. J. Wig, chairman, was presented in his absence by the secretary, Mr. V. G. Marani.

On motion of Mr. Marani, the following were accepted for publication as tentative standards of the Society:

Proposed Tentative Specifications for Gypsum;

Proposed Tentative Specifications for Calcined Gypsum;

Proposed Tentative Methods for Tests of Gypsum and Gypsum Products.

Mr. Marani then moved that the proposed Tentative Specifications for Gypsum Plaster be accepted for publication as a tentative standard of the Society.

Mr. Richard L. Humphrey moved an amendment that these specifications be printed in the Proceedings as a tentative report on Gypsum Plaster, and that the Executive Committee of the Society be requested to decide the question of including in standard specifications for materials, requirements covering such matters as application and workmanship, and recommended practice in general. This amendment and the original motion, as thus amended, were then adopted.

On motion of Mr. Marani, the tentative report of the committee on Design of Reinforced Gypsum Beams was accepted for publication in the Proceedings.

The following papers were then presented by their authors and discussed jointly:

"Proportioning of Pit-Run Gravel for Concrete," by Mr. R. W. Crum;

"Some Theoretical Studies on Proportioning Concrete by the Method of Surface Area of Aggregates," by Mr. R. B. Young.

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[1] These revisions appear in detail in the Addendum to the Report of Committee C-4, pp. 306–307.

A paper entitled "Modulus of Elasticity of Concrete" was then read by its author, Mr. Stanton Walker.

In the absence of the author, Mr. H. W. Green, his paper on "Relation between Methods of Curing Standard Concrete Test Specimens and their Compressive Strength at 28 Days" was read by title.

The meeting then adjourned till 8 P. M.

TENTH SESSION—FRIDAY, JUNE 27, 8 P. M.

Joint Session with the American Concrete Institute on Cement and Concrete.

President G. H. Clamer and President W. K. Hatt of the American Concrete Institute in the chair.

The report of Committee C-1 on Cement was presented by its chairman, Mr. R. S. Greenman.

The report of Committee C-9 on Concrete and Concrete Aggregates was presented by its chairman, Mr. S. E. Thompson. In addition to the printed report, Mr. Thompson presented an appendix entitled "Abrams-Harder Field Test for Organic Impurities in Sand," which on motion of Mr. Thompson was accepted with the report for publication in the Proceedings.

The report of the Committee of the American Concrete Institute on Fireproofing was presented by its chairman, Mr. W. A. Hull.

The following two papers of the American Concrete Institute were then presented by their respective authors:

"Fire Tests of Concrete Columns," by Mr. W. A. Hull;

"Strainagraph and its Application to Concrete Ships," by Mr. F. R. McMillan.

The following two papers were then presented by their authors and discussed:

"Effect of Fineness of Cement," by Mr. D. A. Abrams;

"Cements Producing Quick-Hardening Concrete," by Mr. P. H. Bates.

There being no further business, President Clamer then declared the meeting of the American Society for Testing Materials adjourned *sine die*.

APPENDIX I.

MEMBERS PRESENT OR REPRESENTED.

A

- Abbott, R. R.
- Abrams, D. A.
- Aertsen, G.
- Affleck, B. F.
- Agg, T. R.
- Ahlbrandt, G. F.
- Aiken, W. A.
- Ajax Metal Co.,
  - G. H. Clamer.
- Ajax Rubber Co.,
  - H. B. Underwood.
- Akin, T. B.
- Allen, J. T.
- Aluminum Castings Co.,
  - E. H. Dix.
- Aluminum Company of America,
  - R. L. Templin.
- American Brass Co.,
  - Alden Merrill.
- American Bridge Co.,
  - W. G. Grove.
- American Bronze Corporation,
  - Rehfuss Dittman.
- American Bureau of Shipping,
  - G. G. Sharp.
- American Chain Co.,
  - A. V. DeForest.
- American Institute of Architects,
  - D. K. Boyd.
- American Locomotive Co.,
  - F. J. Cole.
- Amies Road Co.,
  - W. T. Newcomb.
- Antisell, F. L.
- Arco Co.,
  - F. A. Coates.
- Ashton, Ernest.
- Asphalt Association,
  - J. E. Pennypacker.
- Association Metal Lath Manufacturers,
  - Wharton Clay.
- Association of American Steel Manufacturers,
  - J. O. Leech.
- Aston, James.
- Atlantic Refining Co.,
  - T. G. Delbridge.
- Aupperle, J. A.

B

- Baldwin Locomotive Works, The,
  - J. A. Hance.
- Baltimore and Ohio Railroad Co.,
  - J. R. Onderdonk.
- Barrett Co., The,
  - W. S. Babcock.
- Barton, L. E.
- Bates, P. H.
- Baxter, H. A.
- Beck, W. J.
- Beckstrand, E. H.
- Bell, F. B.
- Berger, E. H.
- Berry, H. C.
- Bethlehem Shipbuilding Corporation, Ltd.,
  - Fore River Plant.
  - H. P. Phelps.
- Bethlehem Steel Co.,
  - R. M. Bird.
- Bierbaum, C. H.
- Birdsboro Steel Foundry and Machine Co.,
  - J. E. McCauley.
- Blackmer, L. G.
- Blair, Will P.
- Blakeley, A. G.
- Blanchard, A. H.
- Bleininger, A. V.
- Boeck, P. A.
- Borgner, Cyrus Co.,
  - Cyrus Borgner.
- Boyer, E. D.
- Boynton, C. W.
- Brace, P. H.
- Bragg, J. G.
- Braid, A. F.
- Bridgeport Brass Co.,
  - W. Reuben Webster.
- Brighton Mills,
  - W. O. Jelleme.
- Brown, H. J.
- Brown, G. S.
- Brunner, John.
- Buck, D. M.
- Buffalo, Rochester, Pittsburgh Railway Co.,
  - Frank Henry.
- Bull, R. A.

Bultman, F. H.
Bultman, F. H. Jr.
Bureau of Construction and Repair, U. S. N.
    W. J. Baxter.
Burgess, G. K.
Burrows, Charles W.
Byers Co., A. M.,
    James Aston.

C

Calumet Steel Co.,
    A. S. Hook.
Cambria Steel Co ,
    G. E. Thackeray.
Camden Forge Co.,
    G. N. Losee.
Canby, W. P.
Capp, J. A.
Carnegie Steel Co.,
    C. F. W. Rys.
Carpenter Steel Co.,
    J. H. Parker.
Carroll, W. C.
Cavender, John H.
Central Iron and Steel Co.,
    R. H. Irons.
Chase, C. E.
Cheesman, F. P.
Chicago, Burlington and Quincy Railroad Co.,
    Frank Zeleny.
Chicago and Northwestern Railroad,
    G. M. Davidson.
Chicago, Rock Island and Pacific Railway Co.,
    C. L. Buckingham.
Christie, A. J.
Church, S. R.
Claiborne, C. H.
Clark, Cyril B.
Clay Products Association,
    G. H. Tefft.
Cleveland, Cincinnati, Chicago and St. Louis Railroad,
    E. B. Hall.
Coates, John B.
Cohen, A. B.
Cohen, F. W.
Colonial Steel Co.,
    N. B. Hoffman.
Columbia Steel and Shafting Co.,
    E. T. Ickes.
Comstock, G. F.
Concrete Products Co.,
    C. F. Buente.
Condit, E. A.
Congoleum Company, Th
    R. D. Bonney.
Conn, C. F.
Connolly, R. D.
Conradson, P. H.
Conroy, L. W.
Cook, O. U.
Cooke, G. W.
Cooper, W. A.
Corse, W. M.
Cosden and Co.,
    C. K. Francis.
Cowan, W. A.
Cramp and Sons Ship and Engine Building Co., The William A.,
    W. A. Dobson.
Crandell, J. S.
Crescent Portland Cement Co.,
    O. C. Hasse.
Crockett, A. E.
Cromwell, O. C.
Crowe, J. J.
Crum, R. W.
Curtis, M. S.
Cushman, A. S.

D

Dallas, C. D.
Damascus Bronze Co.,
    W. K. Frank.
Davies, G. C.
Davis, E. T.
Davis, J. J.
Davis, R. P. M.
Davis, S. D.
Davis, S. L.
Davis, Watson.
Davis Library of Highway Engineering,
    A. H. Blanchard.
DeFrain Sand Co.,
    J. L. Durnell.
Denver and Rio Grande Railroad.,
    P. C. Witherow.
Department of Engineering, City of Rochester,
    H. L. Howe, Jr.
DeVoe and Raynolds Co.,
    G. S. Whitley.
Devries, R. P.
Dibble, R. H.
Diller, H. E.
Doke, G. E.
Donaldson, W. E.
Douty, D. E.
Dow, Allan W.

Dow Chemical Co.,
    M. Y. Seaton.
Draney, J. R.
Dunbar, W. O.
Dunham, W. E.
Dunn, B. W.
DuPont Experimental Station,
    Hamilton Bradshaw.

E

Earley, J. J.
Eastern Malleable Iron Co.,
    W. R. Bean.
Ecolé Polytechnique Library,
    Joseph Haynes.
Edgerly, D. W.
Edwards, E. J.
Edwards, L. N.
Edwards, W. F.
Egan-Rogers, Steel and Iron Co.,
    J. I. Rogers.
Emerson, J. B.
Emley, W. E.
Engineering News-Record,
    E. J. Mehren.
Erie Forge Co.,
    G. W. J. Stout.
Erie Railroad Co.,
    J. A. Munsell.
Evans, L. L.

F

Fafnir Bearing Co.,
    C. T. Hewitt.
Fahy, Frank P.
Faragher, W. F.
Felton, G. E.
Fieldner, A. C.
Finn, A. N.
Firestone Tire and Rubber Co.,
    Fred. Taylor.
Flowers, A. E.
Force, H. J.
Forrest, C. N.
Fort Pitt Malleable Iron Co.,
    A. M. Fulton.
France, G. P.
Franklin Steel Co.,
    E. E. Hughes.
Frasse and Co., Peter A.,
    Lester Brion.
Freeman, J. E.
Fritch, G. M.
Froehling and Robertson,
    H. C. Froehling.
Fry, L. H.
Fulweiler, W. H.

G

Gardner, Harry.
Gardner, H. A.
Gates, J. S.
Gebert, N. J.
Geiser, W. B.
General Electric Co., Lynn Works,
    J. M. Darke.
General Electric Co., Schenectady Plant,
    J. A. Capp.
General Electric Co., Pittsfield Plant,
    E. A. Snyder.
Geological Survey of New Jersey,
    R. B. Gage.
Glass, G. G.
Goldbeck, A. T.
Goodell, J. M.
Goodyear Tire and Rubber Co.,
    E. H. Barnwell.
Grand Trunk Lines in New England,
    George T. Huelin.
Granite Paving Block Mfrs. Association,
    A. T. Rhodes.
Gray, G. W.
Green, J. L.
Greene, H. L.
Greenman, R. S.
Griffith, R. E.
Grove, W. G.
Gundlach, H. R.
Gulick-Henderson Co.,
    C. S. Bilyeu.
Gypsum Industries Association,
    V. G. Marani.

H

Hagy Waste Works, J. Milton,
    R. L. Hays.
Haigh, D. L.
Halbing, J. E.
Hall, Clarence.
Hall, J. H.
Hammer, A. E.
Hammond, G. T.
Harding, W. H.
Hartshorn, C. L.
Hartwell, S. W.
Hartzell, H. S.
Harvey, Dean.
Haswell, J. C.
Hatt, W. K.
Hawk, L. C.
Hay, J. T.
Hayward, O. C.
Headley Good Roads Co.,
    W. T. Headley.

Heckel, G. B.
Heckel, James E.
Henry, John A.
Hering, Rudolph.
Herschel, W. H.
Hess-Bright Manufacturing Co.,
  E. W. Rubencame, Jr.
Hewitt Rubber Co.,
  H. F. Jefferson.
Hibbard, W. R.
Hibbs, M. E.
Hicks, T. A.
Hill, J. C.
Hollister, S. C.
Holst, J. L.
Holstein, L. S.
Holz, H. A.
Hopkins, G. A.
Hough, N. G.
Howard, L. E.
Howe, R. M.
Hubbard, Prevost.
Hudson Coal Co.,
  L. A. Smith.
Hull, W. A.
Humphrey, Richard L.
Humpton, W. G.
Hunnings, S. V.
Hunt, R. W. and Co.,
  Robert W. Hunt.

I

Ickes, E. T.
Illinois Steel Co.,
  P. E. Carhart.
Illinois Steel Co., Warehouse Dept.,
  H. N. Copthorne.
Imperial Varnish & Color Co., Ltd.,
  G. C. McEwen.
Ingalls, F. P.
Inland Steel Co.,
  N. C. Jones.
Inland Steel Co.,
  Powell Pardee.
Inspection Department, Associated Factory Mutual Fire Insurance Co.,
  E. A. Barrier.
International Silver Co.,
  J. A. Hutchinson.
Interocean Oil C.,
  L. M. Law.
Iron Age, The,
  A. I. Findley.

J

Jackson, F. H.
Jacquith, H. J.
Jeffers, J. M.
Jefferson, H. F.
Jeffries, L.
Jennison, H. C.
Job, Robert.
Jobson, T.
Johnson, A. N.
Johnson, George A.
Johnson, George T.
Johnson, J. B.
Johnson, N. C.
Johnson, R. P.
Johnson, T. J.
Johnston, R. S.
Jones, Jesse L.
Jones and Laughlin Steel Co.,
  A. Milne.

K

Kansas City Southern Railroad,
  H. L. Roscoe.
Kelley Island Lime and Transport Co.,
  F. A. Jones.
Kelley, F. W.
Kelley, L. E.
Kennedy, E. F.
Kenney, L. H.
Kerlin, W. D.
Kernan, F. M., Jr.
Kerr, H. D.
Kershaw, W. H.
Kier, P. S.
Kingdon, F. H.
Kirchner, Paul.
Klein, W. H.
Knowlton, H. N.
Kouwenhoven, W. B.

L

Lackawanna Steel Co.,
  F. E. Abbot.
Lafayette College Library,
  E. C. Bingham.
Lagaard M. B.
La Marche, C. F.
Lane and Co., J. H.
  C. B. Finckel.
Lanza, Gaetano.
Lasier, E. L.
Lawson, T. R.
Lee Tire and Rubber Co.,
  D. F. Cranor.
Leech, J. O.
Leeds and Northrup Co.,
  Henry Brewer.
Lehigh Valley Railroad Co.,
  S. E. Printz.
Lenhart, J. M.

Lesh, Ira B.
Lesley, R. W.
Lewis, J. T., and Brothers Co.,
    L. T. Beale.
Libberton, J. H.
Lime Association, The,
    R. F. Hall.
Lindau, A. E.
Lindsay, R. W.
Litchfield, Norman.
Little, A. D., Inc.,
    H. L. Sherman.
Lober, W. D.
Locomotive Superheater Co.,
    H. B. Oatley.
Love, H. J.
Lukens Steel Co.,
    W. G. Humpton.
Lumen Bearing Co.,
    N. K. B. Patch.
Lunn, C. A.
Lynch, T. D.

M

MacFarland, H. B.
MacGregor, J. R.
Mackenzie, K. G.
MacPherran, R. S.
Maine Central Railroad,
    P. M. Hammett.
Manhattan Rubber Mfg. Co.,
    W. L. Sturtevant.
Manhasset Mfg. Co.,
    H. T. Viall, Jr.
Margerum, C. E.
Marion Steam Shovel Co., The,
    R. A. Young.
Marston, Anson.
Marquette Cement Mfg. Co.,
    R. B. Dickinson.
Marsh, C. P.
Masury and Son, J. W.,
    F. P. Ingalls.
Mathias, D. L.
McAdam, J. D., Jr.
McIntyre, W. A.
McLeod, John.
McMillan, F. R.
McNaugher, D. W.
McNiff, G. P.
Merica, P. D.
Meriwether, Coleman.
Merriman, Mansfield.
Meyer, A. L.
Michigan Central Railroad,
    G. E. Parks.
Midvale Steel and Ordnance Co.,
    G. L. Kelley.
Milburn, Henry M.
Miller, A. R.
Miller, G. A., Jr.
Miller, Rudolph P.
Millwood, J. P.
Missouri Malleable Iron Co.,
    F. E. Nulsen.
Mitchell, J. R.
Mohr, Charles T.
Moore, J. K.
Moore, H. F.
Morgan Engineering Co., The,
    J. B. Hammond.
Mory, A. V. H.
Murphy Varnish Co.,
    W. F. Burleigh.
Mussey, W. H.

N

Nashville, Chattanooga, and St. Louis Railway Co.,
    G. F. Blackie.
National Association of Corrugated Fibre Box Manufacturers,
    B. C. Tomlin.
National Cash Register Co.,
    E. C. Carter.
National Conduit and Cable Co.,
    H. A. Shaw.
National Malleable Castings Co.,
    H. A. Schwartz.
National Sugar Refining Co.,
    J. W. Schlagel.
National Tube Co.,
    F. N. Speller.
Nead, J. H.
Nellis, J. C.
Newcomb, R. E.
New Jersey Zinc Co.,
    W. H. Hendricks.
Newlin, J. A.
Newport News Shipbuilding and Drydock Co.,
    J. W. Gray.
New York Central Railroad,
    Charles B. Martin.
New York Central Railroad Co., Engineering Dept.,
    A. W. Carpenter.
New York, New Haven and Hartford Railroad,
    H. P. Hass.
Norris, G. L.
Northern Malleable Iron Co.,
    F. R. Angell.
Northern Pacific Railroad Co.,
    H. G. Burnham.
Nusbaum, C.

O

O'Connor, J. F.
Operative Plasters and Cement Finishers Association of the United States and Canada,
W. J. Wilson.
Organ, T. O.

P

Packard Motor Car Co.,
W. C. Peterson.
Patton Clay Manufacturing Co.,
G. E. Prindible.
Patton Paint Co.,
C. H. Hall.
Paul, C. E.
Pearson, J. C.
Pease, B. H.
Peerless Drawn Steel Co.,
F. R. Bonte.
Pennsylvania Forge Co.,
E. T. Walton.
Pennsylvania Railroad, Eastern Lines,
F. M. Waring.
Philadelphia and Reading Railway,
J. B. Young.
Pennsylvania Seaboard Steel Corporation,
T. Burd Zell.
Phillips, Asa E.
Pickard, Glenn H.
Pittsburgh Testing Laboratory,
W. F. Carpenter.
Pollak, J. A.
Pollock, C. D.
Porter, H. C.
Porter, J. M.
Portland Cement Association,
W. M. Kinney.
Potts, S. C.
Pressed Steel Car Co.,
J. F. Streib.
Price, William B.
Pullar, H. B.

Q

Quinn, Don L.

R

Ramsay, J. D.
Randall, T. A.
Raritan Copper Works,
S. Skoweonski.
Rawdon, H. S.
Reading Iron Co.,
E. F. Blessing.
Reeve, C. S.
Reinhardt, G. A.
Remington Arms and Ammunition Co.,
N. A. Chase.
Republic Rubber Co.,
L. A. Watts.
Research Laboratory, General Electric Co.,
W. E. Ruder.
Rettew, E. W.
Rhode Island Tool Co.,
A. H. Annan.
Rice, W. W.
Robbins, C. W.
Rochester Bureau of Municipal Research,
J. O. Preston.
Rockwood, W. C.
Roebling's Sons Co., John A.,
H. C. Boynton.
Rogers, R. E.
Rome Iron Mills, Inc.,
C. C. Osterhaut.
Roscoe, R. E.
Rosengarten, W. E.
Royle and Sons,
V. E. Royle.
Ryerson and Son, Joseph T.,
H. A. Gray.
Rys, C. F. W.

S

Sabin, A. H.
Sanderson, John McE.
Sanford, R. L.
Sargent, G. W.
Schaeffer, J. A.
Schmid, M. H.
Schmitt, F. E.
Schonthal, D. C.
Schwartz, H. A.
Scott and Co., H. L.,
H. L. Scott.
Seaboard Airline Railroad,
S. B. Andrews.
Seaton, M. Y.
Security Cement and Lime Co.,
L. A. Cover.
Semet-Solvay Co.,
T. S. Harvey.
Sewer Pipe Manufacturers Assoc.,
J. L. Rice.
Sharples, P. P.
Shelley, H. T.
Shepherd, B. F.
Sherman, H. L.
Sherwin-Williams Co.,
E. C. Holton.

Shimer, W. R.
Shuman, J. J.
Slater, W. A.
Smith, E. K.
Smith, E. S.
Smith, Francis P.
Smith, H. E.
Smither, F. W.
Snowden, R. C.
Somerset Rubber Reclaiming Work,
    C. B. Clark.
Souther Engineering Corporation, Henry,
    J. A. Newlands.
Southern Pine Association,
    T. R. Johnston.
Southern Railways,
    J. C. Ramage.
Stafford, S. G.
Standard Oilcloth Co.,
    P. A. Bivins.
Standard Steel Works Co.,
    A. A. Stevenson.
Steel Co., of Canada,
    J. G. Morrow.
Steigerwalt, R. W.
Steuer, Bernhard.
Stevenson, A. A.
Stone, George C.
Stowe, C. B.
Stuhler, H. E.
Sweet's Steel Co.,
    C. C. Steel.

T

Tagge, A. C.
Tagliabue, C. J.
Talbot, A. N.
Talbot, K. H.
Taylor Instrument Co.,
    E. N. Hurlburt.
Taylor, A. P.
Tefft, G. H.
Templin, R. L.
Thomas, H. R.
Thomas, I. B.
Thompson, G. W.
Thompson, S. E.
Tiemann, H. P.
Titanium Alloy Mfg. Co.,
    L. E. Barton.
Topping, W. S.
Touceda, Enrique.
Trautwine, J. C.
Tredennick, H. L.
Tretch, W. J.
Trist, N. B.
Turner Co., J. Spencer,
    C. S. Cook.
Turner, H. C.

U

Unger, J. S.
Union Drawn Steel Co.,
    L. W. Williams.
Union Pacific Railroad,
    N. F. Harriman.
United Gas Improvement Co.,
    W. H. Fulweiler.
United and Globe Rubber Manufacturing Co.,
    G. W. Skirm.
United States Gypsum Co.,
    G. L. Southard.
United States Metals Refining Co.,
    R. W. Deacon.
United States Metals Refining Co.,
    F. R. Pyne.
United States Railroad Administration,
    C. B. Young.
United States Rubber Co.,
    A. E. Jury.
United States Shipping Board,
    L. M. Norelius.
United States Smelting, Mining and Refining Co., Inc.,
    F. F. Colcord.
Upham, C. M.

V

Vacuum Oil Co.,
    F. R. Baxter.
Vanderbilt, R. T. Co.,
    A. A. Somerville.
Van Gundy, C. P.
Van Suetendael, A. O.
Vassar, H. S.
Voorhees, Alex. H.
Voorhees, S. S.
Voss, W. C.
Vredenburgh, Watson.

W

Waclark Wire Co.,
    R. T. Roberts.
Walker, H. G.
Walker, P. H.
Warwick, C. L.
Washington Steel and Ordnance Co.,
    S. V. Hunnings.
Wason, L. C.
Watson, J. M.
Webert, L. P.
Webster, G. S.

Webster, W. Reuben.
Weiss, J. M.
Wertz, F. A.
Westinghouse Air Brake Co.,
  H. C. Loudenbeck.
Westinghouse Church Kerr and Co.,
  C. M. Chapman.
Westinghouse Electric and Manufacturing Co.,
  T. D. Lynch.
Weymouth, F. A.
Whipple, A. D.
Whitaker-Glessner Co., Portsmouth Works,
  G. W. Moore.
White, G. D.
White, J. A.
Whittemore, H. L.
Whittier, E. S.
Wickhorst, M. H.
Williams, G. M.
Williams, L. W.
Wirebounds Corporation,
  G. C. Babcock.
Wood, E. T.
Wood, Walter.
Wood Iron and Steel Co., Alan,
  W. A. Cooper.
Woodroffe, G. H.
Woodward, R. W.
Woolson, I. H.
Worcester Tire Fabric Co.,
  C. R. Brownell.
Wormley, P. L.

Y

York Manufacturing Co.,
  Fred L. Hiller.
Young, C. D.
Young, R. B.
Youngstown Sheet and Tube Co.,
  G. A. Reinhardt.

Z

Zeidler, J. L.

Edgar Marburg.

From the Painting by
J. McLure Hamilton.

Edgar Marburg

1864—1918

✠

The American Society for Testing Materials in annual meeting assembled learns with profound sorrow of the death of its esteemed Secretary-Treasurer, Edgar Marburg, on June 27, 1918.

In this hour of bereavement, the Society desires to place on its records an acknowledgment of the great debt which it owes to Edgar Marburg. By zeal, industry, loyalty, insight and high ability exerted through sixteen years as Secretary-Treasurer of the Society; by guiding its actions, energizing its activities, and guarding its name, he has exercised a powerful influence on the character, standing and usefulness of the Society, and on the making of specifications and tests for the materials of engineering. He is honored and revered as a master and leader. The imprint of his work will long remain.

The Society extends to the family heartfelt sympathy for their great loss. May the knowledge that his fine character, strong manhood, and great work in the field of engineering are appreciated by the membership of the American Society for Testing Materials become a part of their many treasured memories of his life and work.

Resolution adopted by the Society at the
Twenty-first Annual Meeting, 1918

Memorial Session

in honor of the memory of

Edgar Marburg

held by the

AMERICAN SOCIETY FOR TESTING MATERIALS

June 24, 1919

PROGRAM OF EXERCISES

The Life and Life-Work of Edgar Marburg
1864–1918

Past-President A. A. Stevenson presiding, the President of the Society, Mr. G. H. Clamer, offered some introductory remarks on behalf of the Executive Committee, and read a resolution adopted by the Executive Committee. The life and life-work of Doctor Marburg in its different phases was then presented by the following speakers:

As an Engineer	John M. Goodell
Early Activities in the Society	Robert W. Lesley
More Recent Service in the Society	Arthur N. Talbot
A Personal Tribute	Robert W. Hunt

Past-President Stevenson then closed the Memorial Session with a brief tribute to Doctor Marburg, the meeting rising in silent tribute to his memory.

ADDRESSES DELIVERED AT THE MEMORIAL SESSION IN HONOR OF THE MEMORY OF EDGAR MARBURG.

INTRODUCTORY REMARKS ON BEHALF OF THE EXECUTIVE COMMITTEE.

By the President, G. H. Clamer.

I have been assigned to make, on behalf of the Executive Committee, a few remarks in testimony of the great esteem, the love, the reverence that the members of your administrative body felt for our departed leader, Dr. Edgar Marburg. He was truly born a leader of men. He wisely, considerately and unselfishly prepared for presentation the problems upon which your Executive Committee was asked to pass judgment. He reached very definite conclusions and presented them with great clearness and ability.

It was not my good fortune to have been a member of your Executive Committee during Doctor Marburg's lifetime. I did, however, attend these meetings informally on two occasions, and the influence of his leadership could not be disguised. He had but to suggest that the facts were as he so clearly presented them and that because of such facts it was his opinion that certain action should be taken: the Executive Committee almost invariably would vote as his judgment indicated. This was so because his judgment was so clean cut, clear and convincing that seldom could they find cause to differ with him. A glance over the annual reports of the Executive Committee during his administration bear mute testimony to his ability and the methodical thoroughness with which his work was accomplished.

My personal acquaintance with Doctor Marburg dates back several years before his affiliation in 1898 with the American Section of the International Association for Testing Materials. I believe that my acquaintance with him had been for a longer period than that of all but a very few of our members. I first knew him when he came to the University of Pennsylvania in a professorial capacity. I then was a student in the Department of Chemistry. I did not come into direct contact with him, but I soon heard of Professor Marburg of the Civil Engineering Department because of his great popularity with the boys. It has been one of my most cherished privileges to have felt his friendship during the entire period of his incumbency in the office of Secretary-Treasurer of our Society.

It was also my privilege to have visited and talked with Doctor Marburg just a few days prior to his death. My last interview with him I shall never forget. He was seated in an invalid's chair in the sun-parlor of the hospital. His words were cheerful and in deep appreciation for the comfort of his surroundings. With him stood his devoted wife and children, heroically giving him good cheer while before them appeared the realization of the inevitable. The loving tenderness and heroism as portrayed in that scene will remain with me always. He chatted in words of good cheer which came laboriously, due to his physical condition. As I left him, he held my hand in tight embrace and said, "Now, old man, you see I have my grip still with me." I assured him that with such a grip he would soon be well, but I felt that I had for the last time held the esteemed hand of Edgar Marburg; and so it happened, for he passed into the great beyond on June 27, 1918, during our last annual meeting.

I wish to present the following minute on the death of Doctor Marburg which was passed at the October meeting of your Executive Committee.[1]

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[1] President Clamer then presented the Minute on the death of Doctor Marburg adopted by the Executive Committee on October 17, 1918, and printed on page 71.—ED.

EDGAR MARBURG'S CONTRIBUTIONS TO ENGINEERING.

By John M. Goodell.

What can be said of the engineering position of a man who sometimes told his acquaintances that he was not an engineer but a teacher? What place can be given to a man whom we all know was saturated with engineering knowledge and devoted his life to the advancement of the engineering profession, yet left no great structures or novel machinery to commemorate his skill?

When we try to measure up the achievements of an engineer we quickly discover that in one respect engineering differs from the other professions. The clergyman or the physician is necessarily an individualist. What he accomplishes is the result of his own learning, forcefulness, tact and personality. The lawyer has to rely somewhat more on his assistants. But the engineer can accomplish little individually; he forges ahead only when aided by others whose work he coordinates into a composite product of details. If each of these details is neither under nor over-elaborated for its purpose in the whole work, it is evidence of the engineering ability of the master mind which achieves the perfectly rounded-out result that is the aim of the highest engineering ambition.

In other words, the engineer is necessarily an executive, in most features of his work, and therein lies the greatest difference between his profession and those of the clergyman, physician and lawyer.

If what has been said is accepted as true, then any attempt to sum up the life work of an engineer in a list of bridges, miles of railway or quantity of machinery neglects the great human element of successful engineering. It is not the structure or the machine calling momentary attention to its designer that is the sole criterion of his professional success. With such things, important though they are, must be considered the influence of his professional standards upon those about him. The men trained in the principles of good construction in the office of a great builder form the most useful result of his professional life. It is because the engineer cannot work alone that the man whose professional services have been mainly in the development of other engineers able to carry responsible duties as builders of structures and makers of machines, deserves a high place. He may do that as a teacher or he may do it in other ways.

It was my good fortune to know Doctor Marburg fairly well for many years, and during a part of that time to rely confidently upon his engineering knowledge and good judgment. He had a perfectly clear appreciation of the subjects upon which he could speak with authority, and the editorials on such subjects which he contributed to the *Engineering Record* were forceful and helpful. It was characteristic of him that he would not discuss publicly subjects upon which he considered his knowledge inadequate to be the basis of sound judgment. His specialty was a restricted one at first, but its limits were gradually broadened and within them he was regarded as a real authority. As a young man he was employed by the Carnegie interests and acquired a knowledge of steel fabrication which proved invaluable in later years. He was closely in touch with all developments of structural engineering. He absolutely refused to be stampeded by the enthusiasm of the discoverers of new metals and new procedures, but he diligently inquired into everything new in his special field. With his wide knowledge, scientific inquisitiveness and good judgment he also had a faculty for clear and concise statement which first found practical use in the preparation under Mr. Strobel of one of the early editions of the Carnegie pocket book for structural steel designers. Although he wrote a number of valuable papers on technical subjects for this and other societies, although his treatise on "Stresses in Framed Structures and Girders" is one of the standard works on the subject, and although the editorial work he did was of distinct service in calling attention to the progress made in his specialty, it is not in his printed words that one will find his greatest service to engineering.

It is difficult to say, even approximately, how wide a circle of engineers has been helped by the personal advice and encouragement given by Doctor Marburg. For some time I have asked engineers whom I met what help they had received from him. The number he has aided proved to be surprisingly large. In his later years, as a result of studies doubtless inspired by his active work with this Society, he acquired a wide and intimate understanding of the materials of engineering which supplemented his really profound knowledge of structural engineering and made him the most helpful of advisers in a great variety of problems. Engineers generally were just acquiring a proper realization of his resourcefulness and his sound judgment in such advisory work when he was taken from us. So far as I can learn this help was generally given in his characteristic direct way. Writing letters he abhored. He liked to talk face to face with the persons consulting him. So, sooner or later, there was a personal interview at which he gave freely whatever information he felt he could impart. It was his marked aversion to lengthy correspondence which renders it difficult to make positive statements about what may be called his consulting activities, although it is questionable whether he dignified them with such a term in his own mind.

Another important feature of his engineering work, to my mind, was the help he gave to many men in responsible positions in choosing engineers for important places. From time to time he was asked to undertake engineering work or to accept important official positions in charge of such work. Some of the older members of this Society will recall the strenuous efforts once made to force his acceptance of the office of Director of Public Works of Philadelphia. None of these offers of places of honor and responsibility attracted him to any extent. He was wrapped up in two things, the engineering department of the University of Pennsylvania and the growth in usefulness and prestige of the American Society for Testing Materials. No inducement could swerve him from this dual allegiance. But it was impossible for a personality so charged with energy and so animated with enthusiasm for sound engineering progress to withhold a helping hand to those coming to him for services. While he would not take the work himself he tendered valuable aid on many occasions in placing engineering duties in hands qualified to dicharge them.

During the last two years engineering had a new and grim aspect. Economy became an incidental factor compared with speed. The man who could design an admirable structure, or machine, or ship, give him all the time and facilities he asked for, had to step aside for the man who could do things overnight without any facilities, although perhaps he did not do them so well. As the enemy's resources became better known, it was as apparent here as over there, that speed was all-important. Every successful drive the enemy made meant losses of appalling quantities of materials in addition to the inevitable great payment in the lives of the best of the Allies and ourselves. Men without materials were of little avail and materials without executive engineers here to produce them were impossible. As the curves of military demands from France and Italy mounted over the curves of production, which they did in all too many cases, and engineers who could make speed became more and more necessary that our men on the battle front might not pay with their lives for our failure to furnish enough munitions and supplies, many times the need for Marburg's intimate knowledge of engineers was felt by those in Washington in charge of personnel affairs. It was learned that he was suffering from a breakdown and was in no condition to stand the strain of wartime work. The help that would have been afforded by his extraordinary ability in judging the technical and executive talents of American engineers would have been priceless eighteen months ago.

To sum up, although he knew how many engineering undertakings should be conducted, he would engage in practically none. His mission as an engineer was, first, to give to engineering students the very best help that wide and accurate knowledge and a deep love of teaching can furnish, and, second, to encourage with entire comprehension and notable enthusiasm all progress in the profession he adorned so well. Marburg's highest record as an engineer is not to be found in structures he designed or in papers and books he wrote, but rather in the great number of engineers who are living more full and more useful professional lives because of the training he gave them or the assistance he rendered in his inspiring, vigorous way.

EDGAR MARBURG—HIS EARLY ACTIVITIES IN THE SOCIETY.

By Robert W. Lesley.

It is both an honor and a privilege to be afforded an opportunity to-night to speak of the early activities of Edgar Marburg in our Society. Marburg and the American Society for Testing Materials to my mind seem almost interchangeable terms, because his life and the life of our organization were so intertwined and interwoven for many years.

To speak fully on the subject it is necessary to go into the history of our Society and look back to its early days in this country, nearly a quarter of a century ago. In 1895 there were six American members of the International Association for Testing Materials, and to-day we have 2481 members in the Society. It was in 1898 that a number of gentlemen connected with the International Association undertook to form an American branch or section. A meeting for organization was held which was presided over by Mr. Gus Henning, the American member of the International Council, and it was decided to form an American section under the presidency of Professor Mansfield Merriman. The first meeting of the section was held at the Engineers' Club in Philadelphia on August 27, 1898. A handful of members were present, and at this first meeting Doctor Marburg took a prominent part in the discussion of a paper which indicated the purpose and intent of the new scientific body. The subject was "In what Manner Will the Adoption of Standard Specifications Improve Industrial Methods and Processes." How materially this discussion on what was subsequently proven to be the key-note of all that the Society has been doing these many years has affected our welfare! And again at the first year's meeting, Doctor Marburg was appointed with Professor Hatt to prepare a paper on "Impact Tests of Materials." This paper, published as Bulletin No. 5 in October, 1899, may be said to be the first definite scientific publication of our Society, and needless to say, when the writers are considered, it was well done, carefully prepared and thought out.

Those early days in which the "old guard," Dudley, Howe, McLeod, Moldenke, Wille, Colby, Humphrey, Hatt, Webster, Stevenson, Merriman, Kreuzpointner and others, to the number of twenty or thirty, attended the annual meetings of the Society, were the "swaddling clothes" days of our organization. When the discussion came up in 1900 as to the relations of the American section with its European parent, Doctor Marburg was one of the thirty-nine petitioners to the International Association demanding recognition of American rights. The little cloud was brushed away, but still the fourth annual meeting in 1901 shows an attendance of only eighteen members, although the membership itself had increased from 70 to 168, with total annual receipts of $370.63. The child had nearly died a-borning for want of active financial support.

In the winter of 1902 it was seen that some vigorous measures were necessary to galvanize the organization into life. In March of that year a letter was presented to the Executive Committee by one of the "old guard," Mr. William R. Webster, in reference to the establishment of a business organization with a paid secretary and definite headquarters. At this meeting Doctor Marburg, by reason of all that he had done for the Society and especially in his successful work with Committee A-1 on Iron and Steel, was selected as the obvious secretary to put the organization on its feet. He then submitted a letter of acceptance, and in a paper on "The American Society: Its Past and Future," presented by me in Doctor Dudley's absence as the presidential address in 1906, I stated that his communication in accepting the office tendered him by the Executive Committee was almost prophetic in its utterances. "Referring first to the changing of the name of the Society, and the suggestion of Professor Tetmajer, of the International Association, that the American branch should be organized as a national body and apply for membership in the parent society as a body, Doctor Marburg recommended that the name should be that of American Society for Testing Materials, and that we should join the International Association as a unit instead of merely as individuals. Referring to the 'future policy,' Doctor Marburg said: 'This I conceive to be the most important topic for our immediate earnest consideration. Manifestly the first concern should be to secure at least a moderate working fund. The next, to initiate a carefully conceived, but vigorous policy calculated to accomplish useful results. The objects for which we stand are of such far-reaching interest and importance that a separate organization for their furtherance will be seen to be amply justified, provided the many-sided opportunities offered be adequately exploited. To present the matter categorically:

"'First. Our Society should serve as the logical outlet for important individual contributions on the part of American scientists and engineers to knowledge of the materials of engineering and appliances used for their determination—be it along physical, chemical or microscopic lines.

"'Second. The standardization of methods of testing and the unification of specifications should be effectively promoted by the work of our own committees, and by judicious cooperation with the committees of other organizations.

"'Third. Our Society should afford unique opportunities for the meeting on common ground of manufacturers, engineers and large consumers. In the broad sense, their interests are not conflicting ones, and every step towards their better reconciliation will be of mutual advantage.

"'Fourth. Our Society furnishes the only medium for establishing closer relations with similar interests in other countries, and thus arriving at a better understanding on questions affecting the commercial exchange of products.

"'Fifth. In recognition of the foregoing, the manufacturers may be properly expected not only to contribute generously towards the legitimate expenses of our Society, but to place their products and, so far as possible, their facilities at our disposal in a reasonable measure, and free of cost, with a view of enabling our committees to prosecute important investigations.'

"With these suggestions in mind, and with the full approval of the Executive Committee, the officials of the Society proceeded to take out a charter under the laws of Pennsylvania, for the American Society for Testing Materials, and prepared to bring the matter of the inauguration of our new Society before the body at the convention at Atlantic City in June, 1902."

This was done and the present body bears witness to the success of the handiwork of its organizers.

Looking back as we are doing to-night, we certainly must all feel how fully these prophetic utterances above quoted have been realized in the work and in the progress of our Society, and appreciate how Doctor Marburg must have enjoyed the fruition of his hopes and suggestions made so long ago.

With the organization of the American Society for Testing Materials, the name suggested by Doctor Marburg in his letter, a new career for the Society began. From this point on we must contemplate the two-fold career of Edgar Marburg in relation to the American Society for Testing Materials. On the one hand, a life full of interest, full of activity, full of purpose, devoted to the highest and broadest aims of the organization, and on the other, a constant struggle with petty details and the carking cares of inadequate funds to carry on its work. An examination of the volumes of Proceedings and of committee work shows how the highest aspirations for thorough cooperation between the producer, engineer and consumer were sustained and maintained, how the publications of the Society took new form in the preparation, printing and editing, and became recognized authorities upon the subjects treated, how the younger men were brought forward to take part in the presentation of papers and their discussion, how cooperation in joint committees was established with sister societies, how the presiding officers had Doctor Marburg always at their elbow, prompt and attentive, ready to assist in every detail of the work at the meetings, and how from year to year the Society climbed from height to height and lived up to the high ideals and standards set up in Doctor Marburg's letter.

This, however, while forming the "cap-sheaf" of his reputation as a scientist and an able executive, was only a part of the work that Doctor Marburg did, and in which he had the valuable assistance of Dudley, Howe, Merriman and of other members of the Executive Committee, all of them devoted to the best interests of the American Society for Testing Materials.

The other side of Doctor Marburg's work was not so agreeable and represents in a way the old Latin saying *per aspera ad astra*—"through the sharp rocks to the stars." This side of his work meant endless care, endless worry, endless anxiety. The growing pains of the child were his portion, and as our organization grew in scientific reputation and increased in membership and in the number of pages in its publications, the growing child, as the Minutes of the early years show, had many a serious financial difficulty. It can be said, however, by those of the Executive Committee who worked with and had the full cooperation of Doctor Marburg, that there never was a time in the history of the Society when he was not ready to sacrifice himself personally and physically for the association to which he was devoting his life. Some of the difficulties he met, such as joining with others in financial obligations of the Society, of becoming guarantor of its publications and of the payment of the printer's bill, of working for the minimum of salary for the arduous labors performed, are all remembered by the "old guard" as marks of his generosity and his devotion.

It must be realized that the American Society for Testing Materials conducted upon any basis but that of the highest ideals and purposes would have been a failure. It was the pioneer in a new art in this country of business and commercialism and its rulings and specifications governed the expenditures of railroads, manufacturers, public authorities, in contracts involving hundreds of millions of dollars. To keep the Society clean, to keep the shield untarnished, to permit no commercialism to cast a breath upon the escutcheon of its fair name and scientific dealings was the work to which Doctor Marburg devoted his days; and when it is considered that during all these years of worry and anxiety he stood for the highest in honor and the highest in conscience and never permitted the Society or any of its members to ever deviate one hair's breadth from the path of rectitude and morals, the memory of the man who stood for what he did in the history of our organization will live forever.

Even later on, when the Society had achieved success and financial cares ceased to trouble, it was Doctor Marburg who relentlessly as a faithful and devoted watch-dog guarded us from commercialism, self-seekers and lowered ideals.

As we all knew Doctor Marburg, he might be said to have had "fighting honesty." He brooked no trifling with matters of conscience, and he converted fair dealing into integrity, honesty into honor, and to those high qualities he devoted his life.

EDGAR MARBURG—HIS MORE RECENT SERVICE IN THE SOCIETY.

By Arthur N. Talbot.

As the growing boy has his problems and his troubles when developing into young manhood, so the growing young society, going along away from beaten paths and into fields not yet explored, must expect to meet difficulties, to encounter hazards, in making a way which it is desired shall become more and more useful to its users. The growth of the American Society for Testing Materials in numbers and in influence in recent years has been marvelous. The energy of its movements in these later years has been remarkable. Its accomplishments for scientific progress, for commercial improvement in contractual relations, have been very great. Further, in this growth and development, it has been essential to the progress of the Society that the possible pitfalls be avoided, that the difficulties be foreseen, and that the many problems hitherto untried be solved. It is due to Edgar Marburg to say that very much of the wonderful vigor and remarkable accomplishment and unstained record of the American Society for Testing Materials has been due to the energy, vision and character of this man. The influence which he exerted on the spirit and policy of the Society and on relations which should control in the organization and in its committees, contributed greatly to the making of the Society. In a variety of ways his work has molded and marked the Society's development.

The continued growth in numbers brought many new problems. When a field has been opened and success in a given line has become assured, it is not unnatural to rest on laurels won. It is not uncommon for the activities to reach a plateau, with a stay of progress, even though that plateau may be high. Such was not the way of Edgar Marburg—expansion, development, growth, higher aspirations were his watchwords. New committees, a broader field, better research, a wider usefulness for the Society were ever in his mind. The results are to be found in the diversity of committees and sub-committees, in the breadth of the technical papers, in the reports of research work.

It is not strange that with the widening activities of the Society the expense of its work outran the limited financial resources which came to it in the way of dues and sales. Doctor Marburg was quick to see that it would not do to have the usefulness of the Society impaired by so low a limit of funds. He was confident that the membership would not resent a marked increase in annual dues, a judgment which brought the timorous ones into line and proved to be correct. It was characteristic of him that he sensed the views of the membership and properly judged what would be acceptable and be appreciated by them.

Doctor Marburg was greatly interested in the International Association for Testing Materials. He should be given much credit for his work in connection with the 1912 Congress of the International Association, for although he held himself in the background his work and influence and ideals in preliminary arrangements and plans, in raising funds, and in carrying on the work of the Congress, contributed greatly to the success of the Congress and the entertainment of the large number of foreign visitors. It was characteristic of him, too, that he should insist that the unexpended balance of the fund that was raised for the expenses of the Congress be returned to the contributors as had been promised when the solicitations were made.

As Secretary of the American Society for Testing Materials, he gave unstintedly of his abundance of energy and initiative—a remarkable contribution to the life and achievements of the Society. More striking yet was the influence upon the formation of the policies of the Society and the acts of committees and officers which his high ideals of society integrity and his high standards for committee conduct brought about. Ruggedly honest, always courageous, constantly solicitous for the welfare of the Society and the protection of its good name, he did not hesitate to fight against what might be sinister agencies, to keep the Society free from any possible taint of commercialism, and to make it more and more a power for good. Always recognized as independent and fair-minded, even though somewhat impetuous and never disposed to temporize, his well-known characteristics exercised a restraining influence in many ways. He gave all an opportunity to present views, but he did not spare his terms in characterizing what he thought was detrimental to the honor of the Society or its best interests. With all this went a manly way, a personal interest in all, and an appreciation of others' view-points. Surely the Society has greatly profited by his solicitude for the Society, his high ideals, and his manly character.

Through these years Edgar Marburg showed himself to be a strong and capable executive officer. In touch with every detail, thorough, alive to the effect of every step in any direction, enthusiastic, sympathetic, yet careful in details and conforming to the rules and policies of the Society, he served the Society faithfully and well. A characteristic of his work was the full and complete presentation of matters to the president and executive committee for consideration and decision. It is not to be wondered at that he always had the full confidence and support of every executive committee. The decision was not always according to his views, but full information was given and honest discussion was had, even though the time of the Secretary might have been conserved by his adoption of easier methods. Thoroughness also characterized all his dealings with committees and with members.

Edgar Marburg's main work was in engineering education, where he achieved notable success, but all engineers who deal with engineering materials are thankful that he gave so much time and energy and life to the American Society for Testing Materials. We recognize him as a master and leader in our work. We honor him for the zeal, loyalty, insight, and high ability displayed as Secretary-Treasurer of the Society. We revere him for his fine character, strong manhood, and high ideals. He was the chief agent in making the American Society for Testing Materials a great technical society and a power in the engineering and manufacturing world. With so many of the elements of greatness, with such a record of accomplishments and of service, we must accord Edgar Marburg a high place on the roll of real fame. May his work and his service long be known and appreciated and may his memory long be cherished and loved by all who know the American Society for Testing Materials.

EDGAR MARBURG—A PERSONAL TRIBUTE.

BY ROBERT W. HUNT.

No matter how great may be the intrinsic merits of an organization, be it one of business, scientific research or humanitarian, its success depends upon the individuality of those administering its affairs. This has been true in the history of America's business combinations, philanthropic organizations, and of our technical societies, and notably true of the American Society for Testing Materials. All honor to the men who laid the foundation for the Society by organizing in 1898 the American Section of the International Association for Testing Materials. Upon this in 1902 was founded our present organization, and it was remarkable that the men elected to the Presidency and Secretaryship of the new organization should have proven so efficient that they were continuously in those offices for so many years; the years so vital to the firm establishment of the Society, not only among the technical organizations of the world, but in the respect and confidence of American business, both as represented by purchaser and producer. I doubt if any other man could have, during those years, so well filled the Presidency, and Doctor Dudley's hands were well upheld by Doctor Marburg as Secretary. Certainly those of us who were called to the Presidency during the nine years following Doctor Dudley's death know how loyal and intelligent was the support which we received from Doctor Marburg.

It fell to me to be President of our Society at the time of the holding of the International Congress in this country (September, 1912), and many questions then arose requiring the exercise of tact and good judgment on the part of those representing the American Society for Testing Materials, and never did Doctor Marburg fail not only to appreciate the situation, but also to have the velvet glove with which to handle it. I have been officially connected with a number of secretaries of scientific societies. Among them were men who attained world-wide fame as such officials—men of brilliant attainments, and of great executive ability; and in my judgment, Doctor Marburg ranked among the most able of them.

Others have paid tribute to Doctor Marburg's memory as more particularly relating to his professional life, and it is given to me to pay a more personal tribute; but his personality was so pronounced in all he did that what I have already said belonged to it. Doctor Marburg was most lovable, and while of high mentality, it was that lovability which gave him his greatest power. Always of firm conviction, and never deviating from the line of procedure which seemed to him to be right, at the same time he made those whom he most opposed feel that his opposition had naught of personality. They may have thought he was wrong, but never failed to be convinced that he acted from a conviction of right. I never knew of his having a personal controversy. As a strong, and therefore successful secretary, he had frequently to decline to do that asked of him. He may have made enemies for Marburg the official, but never, I venture, for Marburg the man.

Doctor Marburg was a classmate at the Rensselaer Polytechnic Institute of my loved friend and years long partner, D. W. McNaugher, and they held mutual esteem and affection. Indeed, Mr. McNaugher's high estimate of and affection for Doctor Marburg prepared me also to esteem and love him. As a companion, he was most delightful; as a friend, most intelligent and loyal. He was true to all duties, and therefore a devoted husband, and an affectionate and wise father. Such individualities prove that the scheme of humanity is not a failure, but on the contrary make this life worth living, and by their influence not only give strength with which to meet trials and sorrows, but also add to the blessings of joys. Beloved wife, dear children, we respectfully mingle our sorrow with yours; but with you we rejoice in our blessed memories, and know that we are better, that the world is better, from his having lived.

CLOSING REMARKS BY THE CHAIRMAN

A. A. Stevenson.

EDGAR MARBURG.

His untiring energy was directed by the highest ideals.

Greatly ambitious for our Society, he was most modest for himself. His desire was to see results; his satisfaction, work accomplished.

Now that he is gone his character stands four-square before us with his sterling honesty as a beacon for our inspiration. He was honest in his life, honest in his work, honest in his ideals.

Let us rise in silent tribute to him, recognizing his worth and acknowledging our loss.

Edgar Marburg

BIOGRAPHICAL SKETCH

By C. L. Warwick.

Edgar Marburg, son of Herman Edward and Clara (Juergesen) Marburg, was born on March 4, 1864, at Hamburg, Germany, where his father had sent his family from New Orleans during the Civil War. His father, a man of artistic tastes who had planned to devote himself to the study of languages, became interested in business and came to America in 1847 as representative of a Hamburg business firm. He became a naturalized citizen in 1853, at which time he was a prominent and successful wholesale merchant in New Orleans. The family returned to New Orleans after the Civil War, and in 1875 moved to Shreveport, La. Doctor Marburg was third in a family of four sons and two daughters, all of whom, including both parents, have survived him.

Boyhood and School Days. Doctor Marburg early showed the promise of those qualities of independence of thought and action that were so characteristic of him in later life. It is told of him, for example, that at an early age he learned to tell the time by reasoning it out entirely himself, aided only by the answers to questions that he asked. He attended a private school in New Orleans and later in Shreveport. From the beginning he showed much aptitude for study. His extraordinary mathematical ability was quickly recognized by his teacher at Shreveport, Capt. George E. Thacher, who took a great interest in him, aiding him to advance rapidly in the study of mathematics and its practical applications. His family have to this day a book in which he kept, in neat, orderly arrangement, the solutions of many problems, ranging from simple ones in arithmetic to those in analytic mechanics and the calculus. He made it a rule then never to ask or accept help on any problem, and in this he laid the foundation for that self-reliance which was always evident in everything he undertook.

At the age of fifteen he determined to enter college. Since it was necessary for him largely to assume his own expenses, he left school and worked for the next three years in a wholesale grocery store at Shreveport, studying at nights to prepare for college. Upon the advice of Captain Thacher, and because of his prediliction for mathematics, he decided to study engineering. He prepared for and passed the Freshman examinations at Rensselaer Polytechnic Institute at Troy, N. Y., and in 1882, at the age of eighteen, entered the Institute as a Sophomore.

COLLEGE DAYS. At college he applied himself thoroughly to his studies, taking particular interest in the purely engineering subjects, but not losing the opportunity of indulging his taste for literature. He was interested in class activities, and was well liked both by his classmates and teachers. He was a member of the Rensselaer Society of Engineers and first editor of the *Institute Quarterly*. He completed the course in three years, graduating in 1885 at the age of twenty-one with the degree of Civil Engineer.

One of his classmates and closest friends, Mr. Enrique Touceda, writes of this period of his life:

> "While Marburg was always intensely interested in Institute happenings and was always popular with the student body, and particularly so with his classmates, he was modest and more or less retiring, having little to do with Institute politics. Without being what is known as a 'grind,' his first thought was to make good in his studies, and then to devote as much time as possible to the enjoyment of general college life.
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> "Marburg as a youth was appreciated by his associates as one of sterling worth, very interesting, very entertaining and companionable. He was intellectually vigorous and quick of judgment; always dependable and ready to render a friendly service on the instant."

Doctor Marburg numbered several of his closest friends among his classmates at Troy, and one of his greatest pleasures was to attend the class reunions and renew the college associations which meant so much to him.

WORK WITH ENGINEERING FIRMS. Upon graduation, Doctor Marburg determined to specialize in the field of structural engineering, and in order to obtain as wide and varied an experience as possible in his chosen field, he adopted the plan of going from one bridge or structural company to another, staying at each one until he had gained the experience desired. He first took a position with the Keystone Bridge Company, at Pittsburgh, under Mr. Edwin Thacher, Chief Engineer, at the salary then usually paid to beginners, fifty dollars a month. He soon became expert in the design of plate girder bridges, to which he was first assigned, and afterwards he obtained considerable experience in the design of pin-connected bridges and buildings. In 1887 he left the Keystone Company and went with the Phœnix Bridge Company, at Phœnixville, Pa., for two years. In 1889 and 1890 he was in the Designing and Estimating Department of the Edgemoor Iron Company, Wilmington, Del. (now the Edgemoor Plant of the American Bridge Company), under Mr. C. W. Bryan, now Chief Engineer of the American Bridge Company. Here, among other things, he was engaged for some time upon the design of the old Norfolk and Western Railway Bridge across the Ohio River at Kenova, W. Va., which was replaced in 1912—as chance would have it—by the American Bridge Company. In 1891 he returned to his home in Shreveport, and later in the same year went to Chicago, where he entered the employ of the Carnegie Steel Company. Here, under Mr. Charles L. Strobel, at that time Consulting Engineer of the company, he was engaged upon the work of preparing shop and mill plans for the structural iron work required for the large fireproof Auditorium Building, Chicago. He was also employed in connection with a revised edition of the Carnegie, Phipps and Company Handbook, then in preparation.

During this period of seven years in which Doctor Marburg was actively engaged in practicing his profession, his work was largely devoted to design of various metal structures, such as bridges, viaducts, train sheds and buildings. He became much interested in several phases of structural engineering, notably the design of swing and cantilever bridges, and the design and fabrication of built compression members, upon which he was later considered an authority. Engineers with whom he was associated in these early years of his professional life saw in him those qualities which later won him such distinction. In the words of Mr. Strobel: "Doctor Marburg's splendid qualities of conscientiousness, thoroughness, faithfulness and competency were in evidence then, as they have been so conspicuously in his later life."

HIS WORK AS A TEACHER. In 1892 Doctor Marburg was offered the headship of the Department of Civil Engineering of the University of Pennsylvania, having been recommended to the Provost of the University by a number of engineers. After careful consideration, he gave up plans he had made for engaging in general consulting practice and determined to make teaching his life work. Assuming his new duties in the fall of 1892 with the title of Acting Professor, he was made Professor-in-charge the following year and held that position until his death. Gifted to a remarkable degree with the ability of clearly expounding the principles and fundamentals of engineering, and with an unbounded enthusiasm for the training of young men in his profession, he quickly attained an eminent position as a teacher. From the beginning he placed teaching high in the order of the learned professions, recognizing its obligations and privileges, and appreciating its profound influence upon the welfare of mankind. To him teaching was more than simply a means of earning a livelihood; it was a profession of great responsibility: the training of men who were to carry on the important engineering activities upon which rests, in the end, the welfare of the human race. By example and by precept, he kept before his students the dignity of their profession and the high standard of ethics towards which they should strive.

The interests of his Department and of the students under him were always close to his heart. With the tremendous enthusiasm that he always had for everything he undertook, he worked assiduously for the upbuilding of the engineering school at Pennsylvania. Curriculum and teaching facilities were constantly improved. The school grew rapidly, and soon after 1900 the facilities were far too small for the growing body of students. He and his colleague, the late Dr. Henry W. Spangler, Professor of Mechanical Engineering, prevailed upon the University authorities to erect a new building to house the entire engineering school. Doctor Marburg and Doctor Spangler planned this building, including its extensive laboratories, and it stands to-day as a monument to their wonderful ability. In appreciation of their services, the University conferred upon them the degree of Doctor of Science on the occasion of the dedication of the building in 1906. His ambition of having adequate laboratories and classrooms for the proper growth of the engineering school realized, he devoted himself earnestly to the problems of further development. New courses were added to the curriculum and old ones expanded as knowledge and practice of engineering developed. The courses in his immediate charge were those in structural engineering—mechanics, elementary and higher structures, graphics, and design of steel and concrete structures. These were highly developed, and the course in structural engineering became widely known as one of the best. His experience of years in the teaching of these courses and his desire to facilitate their presentation to students, led to the planning of a treatise on Framed Structures and Girders (Theory and Practice) in three volumes, devoted respectively to fundamental principles of statics and stresses, to the treatment of more complex structures, and to design, construction and erection. The first volume was written during a year's leave of absence and published in 1911, and was most favorably received in engineering schools. Pressure of work, and after some years failing health, made it impossible for him to write the remaining two volumes.

The purely administrative duties as head of the Department and as a member of the University faculty gave opportunity to exercise that ability to "get things done" which was so characteristic of him. The systematic and orderly manner in which he provided for the multitudinous details in a large school was indicative of the attention which he gave to everything he undertook. His abilities were recognized by his associates; for many years he was Secretary of the Faculty of the College Department, and on several occasions he served as chairman of important committees. It was a marked trait in his make-up that he always took committee work seriously; when charged with the responsibility of directing such work, he was never content to let it drift along, but was ever concerned that the desired results should be accomplished as well and expeditiously as possible.

Throughout his life Doctor Marburg kept in close touch with the practice of his profession, not alone from his intense interest in it, but from his conviction that to do so was essential to sound teaching. Through consulting work which he carried on in the early years of his teaching, through wide reading and study and editorial writings, and more particularly through his broad contact later with the engineering problems of the American Society for Testing Materials, he was enabled to maintain that close affiliation with the practical side of his profession so essential to the successful teacher. He was a close student of engineering education, taking for many years a prominent part in the work of the Society for the Promotion of Engineering Education. In the words of one of his life-long associates on the faculty,[1] "it may truly be said that he supplied in himself, through his broad contact with the active side of engineering, a bond between his students and the professional life which they sought to enter. Though not himself a practicing engineer, he showed in his instruction the fullest appreciation of the value of practical illustration and acquaintance with business procedure."

Though strict in the administration of his Department, his absolute fairmindedness and justice could not fail to command the respect and good will of his students, by whom he was affectionately called "the Duke." His interest in the welfare of the student while at college and after graduation was a marked characteristic, and men were quick to take advantage of his ready sympathy and sound advice. He took great pleasure in following the careers of graduates, maintaining a complete card catalog of names, addresses and successive positions which they held. His interest led him to participate actively in the formation of a Pennsylvania Engineering Alumni Society.[2] Many letters have been received since his death from former students expressing their deep sense of personal loss, and not hesitating to attribute much of their success to his influence and example. Such a tribute would have been very dear to him, for he was wont to measure his success as a teacher by the progress and accomplishments of those whom he taught.

One of Doctor Marburg's closest associates in educational work, Prof. William Easby, Jr., has written of his work as a teacher with the rare discernment that his knowledge of him affords.[1]

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[1] See page 77.

[2] See Resolution, page 73.

SECRETARYSHIP OF THE A.S.T.M.

It is not often that one finds a man whose life has been devoted simultaneously to two rather widely different pursuits, in each of which he has attained the highest success. Such a man, however, was Doctor Marburg. To arrange in the order of their importance the two major activities in his life, his work as teacher, and his services as secretary and executive officer of the American Society for Testing Materials, would be difficult, and after all of no real significance. As a teacher, his service was broadly humanitarian; as secretary of the Society, his work, while humanitarian in its broadest sense, was of immediate practical benefit in developing better relations and understanding commercially between producers and consumers of materials and in advancing the knowledge of materials of engineering. The economic importance alone of the work of standardization of specifications and tests for materials by the Society, which he did so much to make possible, cannot be over-estimated.

Actively interested in questions relating to materials, it was natural that he should aid in the organization in 1898 of an American Section of the International Association for Testing Materials, in which a small coterie of American engineers had held membership for several years. At the first meeting the key-note of the new Section was struck in a discussion on the subject "In What Manner Will the Adoption of Standard Specifications Improve Industrial Methods and Processes," thus showing from the beginning a desire to strike out into a phase of work that was not engaged upon by the International Association, which limited the scope of its activities to the study of properties and tests of materials. For four years the Section endeavored to proceed with the standardization of specifications, in which Doctor Marburg took an active part; but progress was difficult, the objects were not well understood, producers and consumers alike were hesitant of engaging in the preparation of specifications, membership increased but slowly, and there was but little financial support. As one of the members at that time has put it, "the child had nearly died a-borning." In 1902, with vitality at a low ebb, it was seen to be necessary to secure a secretary who by reason of executive ability, courage and determination in the face of odds, and conviction in its ultimate success, could galvanize the organization into life. The Executive Committee turned to Doctor Marburg, whose undoubted qualifications were already recognized, and whose position as an independent engineer and experience in the secretarial work of the pioneer Committee of the American Section on Iron and Steel peculiarly fitted him for the responsibility. He accepted the position of Secretary, and upon his recommendation the Section was incorporated as the American Society for Testing Materials and joined the International Association as a body. In his letter of acceptance to the Executive Committee, he outlined in a masterful way the objects for which the Society should stand.[1] Again, shortly before the annual meeting in 1902, we find him writing:

> "I think that one of the prime functions of our body should be the standardization of specifications; that leadership in this important matter belongs logically to our Society; that it is the only one devoted exclusively to the materials of engineering; that it is the only one in which engineers, scientists, manufacturing corporations, railroad companies, scientific societies, etc., hold membership jointly and have equal voice and vote in all matters that come up; that opportunities thus afforded for meeting on common ground for joint discussion and joint committee work are bound to lead to better mutual understanding and to redound to the interest of all concerned. . . . .
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> "I think it would be well to lay a good deal of emphasis on the fact that the task of our Committee on Specifications must, in the nature of things, remain a never-ending one; that in these days of progress the standards of to-day are not the standards of to-morrow; that in acting as a sort of arbiter between the manufacturer and consumer in the matter of specifications a vast deal of good to all concerned can be accomplished. . . . .
>
> "In the measure in which we shall show ourselves worthy of the respect and confidence of all parties in interest, in that measure will our influence grow and our opportunities for useful service expand."

Thus, in this clear-minded, straight-forward way, Doctor Marburg stated his conception of the functions and opportunities for service of the Society, and who of us to-day can but feel that to such vision, and the ability to "carry on," the Society owes a large measure of the success that it has attained?

With characteristic determination and enthusiasm, Doctor Marburg set about organizing the work of the new Society. Moderate financial support was assured by contributions from various manufacturing and other interests, new committees were organized, other industries were induced to interest themselves in the work of the new society, and slowly but surely the

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[1] These have been included by Robert W. Lesley in his address on "Edgar Marburg: His Early Activities in the Society"; see page 47.

Society began to accomplish useful results and to obtain recognition of its importance. Ably assisted by strong men of the type of Charles B. Dudley, former chemist of the Pennsylvania Railroad and President of the Society from 1902 till his death in 1909, possessed of high ideals of attainment and capable of courageous action in the face of criticism and opposition when convinced of the wisdom of a given plan of action, it is not to be wondered that the Society under his guidance eventually began to command the respect and confidence of the business and technical worlds and to assume the place that he had predicted for it in 1902.

Others have written[1] ably of Doctor Marburg's early and more recent activities in the Society: a chronicle of achievement that will ever stand as an inspiring page in the history of the Society. No labor was too arduous, no sacrifice too great, for the Society which he loved. Thorough in every detail of his executive administration; having a clear grasp of the many and varied problems that came before him and to an unusual degree that facility of expression which enabled him to present so ably the sound views which he formed; and with it all a sympathetic understanding of humanity that at once enabled him to gain the confidence of those with whom he had to deal, it can be truthfully said of him, in the words of an editorial comment written shortly after his death,[2] "The Society was his—his in the sense that his personality more than that of any other individual was determinative of its methods and of its work." In fact, so close was he to every significant development of the Society that it is difficult to chronicle even a few of his more notable achievements. In the handling of financial problems, he was strong, resourceful, and always confident of the support of the members, as, for example, in 1910 and again in 1916, when it was found necessary to increase the dues in order to carry on effectively the work of the Society. In the organization of the many committees of the Society, his appreciation of their problems and his ability to select the right men to carry the responsibilities of their work, were a large factor in the success of this important phase of the Society's activities. In the development of policies relating to committees, standards, presentation of papers, etc., his wisdom and foresight are clearly seen. In planning the programs and arranging the many details of the annual meetings, he contributed largely to their interest and pleasures. His editorial ability is reflected in the high technical standard of the Society's publications. An enthusiasm and zeal pervaded everything he did, and communicated itself to all who were associated with him in the Society's activities. A most notable characteristic was his jealousy of the good name of the Society, and his determination that nothing should be done that would reflect upon its integrity.

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[1] See pages 47–54.

[2] *Engineering News-Record*, July 4, 1918, p. 50.

That his remarkable services to the Society were fully appreciated by the members is testified in the Resolution[1] adopted at the annual meeting in 1918, on the day after his death, expressive of the debt they owe to him, and the realization that his character and personality have indelibly impressed themselves upon the Society, an inspiration for all time. As a fitting memorial, the Society, through individual subscriptions from its members, has endowed the Edgar Marburg Memorial Scholarship in his own school, the Department of Civil Engineering of the University of Pennsylvania, commemorating for all time the name of one who devoted his life to the development of young men into engineers worthy of the great profession that he himself so well adorned.

OTHER ACTIVITIES. While Doctor Marburg can truthfully be said to have been wrapped up in just two things,—the engineering department of the University and the American Society for Testing Materials,—he nevertheless found time for other activities. During his entire life at the University, he maintained an active interest in the Engineers' Club of Philadelphia. Elected to membership in 1893, he served as a Director in 1895 and 1896, and as President in 1900. He contributed in no small measure to the successful accomplishment of many developments of the Club. He served ably in 1912 as first chairman of the Committee on Public Relations, and was also a Trustee of the Bond Redemption Fund. In the earlier years of his membership he was active in the discussions of technical subjects at Club meetings, and in 1896 he presented a paper on Cantilever Bridges which he afterwards used in his classes in structural design.

It was also during the earlier years of his professorship that he engaged more or less actively in consulting work, of which probably the most notable instance was the preparation of a design for a massive arch bridge over Rock Creek, on the line of Massachusetts Avenue, Washington, D. C., under commission from the Corps of Engineers, U. S. Army. In later life he found the duties of his dual position too exacting to permit of consulting work. Nevertheless, he followed closely the developments in the field of structural engineering, and his general engineering knowledge and good judgment were frequently called into requisition by the *Engineering Record*, to which he contributed many editorials on structural subjects.

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[1] See page 39.

A bibliography of Doctor Marburg appears at the close of this sketch of his life.

A man of Doctor Marburg's attainments would inevitably be sought after by others. He was several times offered important engineering positions, among them that of Director of Public Works of Philadelphia, and on at least one occasion was offered a high position in another educational institution of first rank. These offers, however, seemed to hold no attraction for him, and he would not consider a change of his activities.

Among other positions of honor which he held were Lecturer (in 1904) on Structural Engineering at the Franklin Institute of Philadelphia, Chairman of the Institute's Committee on Science and the Arts, and President of the Pennsylvania Chapter of the honorary scientific Society of Sigma Xi. He was a member of the American Society of Civil Engineers, and a member (and for one year secretary) of the Society for the Promotion of Engineering Education. As previously related, he was given the degree of Doctor of Science by the University of Pennsylvania in 1906, and in 1914 was honored with the degree of Doctor of Laws by Franklin and Marshall College.

Personal Traits. Like all men of strong personality, Doctor Marburg possessed many sterling traits of character that have made a lasting impression upon all who knew him. No more honest man could have lived. He was not only honest in every-day dealings—he was honest in everything in his life, in every word, thought and act. It has been said of him that he had the quality of "fighting honesty." He was sincere and direct in all his dealings. When asked to give an opinion, he would do so with entire frankness, no matter how adverse the criticism. He was outspoken; one never doubted his position on any matter in which he was required to express his views. He had no time for devious methods of doing things; he tried to accomplish results as directly as possible, yet he was not lacking in ability to deal tactfully with situations requiring the exercise of that virtue. It was inevitable, during so long an official life, that there should be those whose views differed perhaps radically from his, but it is safe to say that no one ever doubted for a moment the honesty and sincerity of purpose which determined his views and actions. As one of his friends has put it: "He may have made enemies for Marburg the official, but never, I venture, for Marburg the man."

As a man Doctor Marburg was an unfailing optimist, with a cheerful outlook upon everything in life. He put into his work all the enthusiasm and ardor that a man of his temperament would command. He believed in accomplishing the best results with the means at hand, and in making some progress rather than none at all. A favorite motto was "Do your best and leave the rest." He bore with becoming modesty the honors and success which came to him, content that the results for which he worked had been attained. His joy was in the doing, not in the acclaim.

As a friend he was loyal, sympathetic and generous, always ready to be of help either by word or deed. By nature somewhat reserved, it remained for those who came closer to him to realize the warmth and sincerity of his affection.

To Doctor Marburg was vouchsafed for many years that most wonderful happiness of all—love of wife and children. On August 14, 1893, Edgar Marburg and Fanny Dulany Moncure were married at Shreveport, La., and to them were born four children, Frances, Edgar, Clara and Anita. He was a devoted husband and an affectionate father, and the happiness of his home life was beautiful to see.

Doctor Marburg died of a complication of diseases at the University Hospital in Philadelphia, Pa., on June 27, 1918, at the age of fifty-four, after an illness of five weeks which had been preceded by a period of ill health of over a year. His untimely end was undoubtedly hastened by the tremendous burdens under which he so willingly labored.

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RESOLUTIONS, MINUTES AND NOTICES
ON THE DEATH OF
EDGAR MARBURG.[1]

MINUTE ADOPTED BY THE EXECUTIVE COMMITTEE OF THE AMERICAN SOCIETY FOR TESTING MATERIALS.

OCTOBER 17, 1918.

In the death of Edgar Marburg, which occurred on June 27, 1918, the American Society for Testing Materials has suffered the irreparable loss of one of its most eminent and distinguished members; its executive officer since its incorporation; a leader in engineering thought and education and in the field of testing materials.

He was one of the small group which, in 1898, organized the American Section of the International Association for Testing Materials. In 1902 he was appointed acting secretary of the Section. He at once prepared for the Executive Committee a clear, comprehensive statement of the purposes of a testing society, as he conceived them, which led to the incorporation of the Society as an independent body. He was elected Secretary and Treasurer of the new society, and to him was entrusted the executive direction of its affairs. From then till his death, a period of sixteen years, he worked assiduously for the success and advancement of the Society. He devoted much time and thought to the work of its technical committees and the standardization of specifications and methods of tests of the materials of engineering, and he shaped the policy under which these essential activities of the Society are conducted. The marked success which has attended the work and growth of the Society, and the interest and pleasures of its annual meetings, have been due in large part to his tireless and painstaking efforts. To his labors he brought great executive and organizing ability, excellent judgment, a clear grasp of the many and varied problems which confronted him, a sympathetic understanding of humanity, tremendous enthusiasm and zeal, and thoroughness in everything he undertook. His high ideals were reflected in every word and act. He was ever jealous of the good name of the Society, and sought throughout his leadership to extend its usefulness in every proper field.

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[1] The Resolution adopted by the American Society for Testing Materials appears on page 39.

To the officers and members of the Executive Committee, who were privileged to work intimately with him, his death brings a deep sense of personal loss and grief. His high integrity, his rugged honesty, his open-mindedness, and his evident sincerity of purpose, endeared him to his associates, and commanded their admiration, respect and devotion.

The character and personality of Edgar Marburg have indelibly impressed themselves upon the American Society for Testing Materials—an inspiration to the Society for all time.

RESOLUTION ADOPTED BY THE FACULTY OF THE TOWNE SCIENTIFIC SCHOOL, UNIVERSITY OF PENNSYLVANIA.

OCTOBER 8, 1918.

Moved by a profound sense of loss, this Faculty deems it a privilege to here record its estimate of the character and attainments of a colleague, who, although removed by death, has left an abiding influence for good through the vitality and idealism of his life work.

The career of Edgar Marburg, shortened by its very excess of self-giving, nevertheless had long yielded him a distinguished position among engineers and educators. This was due to exceptional force of character and intellectual endowment which, both in preparatory training and professional and teaching activities, placed everything he did on a high plane. His work was marked by clarity and readiness of insight, grasp of essentials and thoroughness of method, and was inspired by high principles and a rugged honesty of view and purpose.

Efficiency of so high an order, addressed to essentials, through more than thirty years of incessant activity, has made the life work of Edgar Marburg a contribution of positive constructive value to the welfare of the community. In two channels particularly has this been demonstrated; the more widely known that of the American Society for Testing Materials, whose great service to the engineering and industrial worlds is due, more than to any other single influence, to his labors. The other channel, invisible but potent, is that of the careers of many students who have passed under his influence, carrying away as fundamental to their action his ideals of professional conduct.

It has been well said of him that he had a constant desire to know the truth and be guided by it: possibly this best explains his life and the reason why we, his colleagues, are moved to add to this summary of his achievements an expression of profound respect for his character and of affectionate regard for the underlying warmth and kindliness of his nature.

To the family of Professor Marburg we offer our sincere sympathy in their bereavement, and while knowing that no mere words can lessen its magnitude we yet venture to hope that consolation may be found in the knowledge that his life, although prematurely ended, has been rich in a usefulness not to be measured by length of days.

Resolved, That the foregoing be adopted as the sense of this Faculty, and spread upon the minutes, and that copies be addressed to the family of Professor Marburg and the professional organizations of which he was a member.

RESOLUTION ADOPTED BY THE ENGINEERING ALUMNI SOCIETY OF THE UNIVERSITY OF PENNSYLVANIA.

AUGUST 1, 1918.

Whereas, In the death of Edgar Marburg, C.E., Sc.D., LL.D., distinguished engineer and educator, the profession of engineering and the University of Pennsylvania suffer the loss of one whose life work and teachings have inspired so many of Pennsylvania's sons to a high conception of their profession; and

Whereas, By his lofty motives, sincerity of purpose, unflagging industry and enthusiasm, he won from his associates and colleagues their admiration, their loyal cooperation, and their loving confidence in his worthiness for his life's greatest work—the training of youth for a career which must ever bear the impress of the impelling guide; and

Whereas, By his investigations and writings he has enriched the science of engineering, especially that branch of engineering relating to "Framed Structures," and, in his capacity of Secretary of the American Society for Testing Materials, he was a chief instrument in the development of that useful and prominent engineering body, and by his great industry and wisdom, he has created, in Pennsylvania's School of Civil Engineering, a monument of engineering education; and

Whereas, In cooperation with his long-time colleague, the late Professor Henry Wilson Spangler, he designed and constructed the Engineering Building and Laboratories, which stand as models in their kind, and founded the Engineering Alumni Society, which binds the alumni in the ties of fellowship, and which so usefully serves our Alma Mater; and

Whereas, By this broad humanity, sound judgment, strict adherence to lofty principles and self-sacrificing devotion to the cause of education and of engineering, he will live in the hearts of our Engineering Alumni as their Professor, and their loyal friend; be it

Resolved, That the Engineering Alumni Society suffers an irreparable loss in the death of Professor Marburg, who by his loving personality, wise counsel and great accomplishments endeared himself to all, and that we hereby extend to his many friends and to his family our sincere sympathy.

RESOLUTION ADOPTED BY THE BOARD OF DIRECTORS OF THE ENGINEERS' CLUB OF PHILADELPHIA.

JULY 9, 1918.

The Engineers' Club of Philadelphia learns with profound sorrow of the death, on June 27, 1918, of its beloved fellow-member and Past-President, Edgar Marburg. The Engineers' Club has, in the death of Edgar Marburg, lost one of its most valued members, whose loyal service has left a deep impression on the history and development of the Club, whose scholarship has earned him an international reputation, and whose personal influence has helped the members in their work and professional advancement.

The Engineers' Club extends to his family its warmest sympathy in their bereavement and sorrow; and, as an acknowledgment of his loyalty, brilliant leadership, kindly sympathy, ready helpfulness and professional ability, it is directed that this resolution of condolence and regret be published in the Journal of the Engineers' Club, together with a sketch of his life.

EXTRACT FROM ENGINEERING NEWS-RECORD.

JULY 4, 1918.

American engineering has lost one of its most useful members in the passing away of Edgar Marburg. He was not only a good engineer but a good teacher of sound engineering practice. As a structural engineer, he won favorable notice while still a young man, and his studies of cantilever bridge design in particular drew general attention to his capacity for original investigation. In his teaching work he took deep and justifiable pride. He had the welfare of his students deeply at heart and strove to develop to the utmost the latent capabilities of each of them. Teaching was a profession to him, not a mere source of steady income to be earned with the least possible work, and his friends had many opportunities to learn that his own personal test of success was the success of the young men he educated.

It is hard to think of the American Society for Testing Materials without also thinking of Marburg and Dudley, ideal secretary and ideal president. The success of this organization was achieved very largely by the enthusiasm and hard work of these two men, who foresaw the important economic results which would follow the standardization of requirements for the materials used in a large part of American engineering construction. The skill with which they made the path smooth for producer and consumer made them at the same time real pioneers of industrial progress. No work was too hard and no controversies too vexatious to check the enthusiasm of Marburg in his activities for this organization.

Marburg's strong personality and readiness to enter the lists to champion any cause he thought needed a defender developed a number of opponents and a host of friends. Every strong man enjoys a good controversy on a worth-while, debatable subject, and Marburg was engaged in a controversy with one or more friends most of the time. They were educational clashes to both sides, and those who had these mental tilts with Marburg learned to admire his resourcefulness and his fairness. In addition, he had that admirable gift in a friend, silence when not asked for an opinion, and complete frankness, no matter how adverse the criticism, when his opinion was asked. He was truly strong in counsel, earnest in purpose, with high ideals and lovable character.

EXTRACT FROM THE IRON TRADE REVIEW.

JULY 4, 1918.

Edgar Marburg is dead, but his great work in standardizing specifications for engineering materials will live and outlast the most colossal pile of marble and granite that might be erected to his memory. That his passing away should have been announced in the midst of the most successful meeting of the Society which he was instrumental in placing in a ranking position among technical organizations of the world was one of the perversities of fate.

To maintain interest in an organization such as the American Society for Testing Materials, whose membership consists largely of producers and consumers with specification provisions in constant conflict, demanded the services of a diplomat. To increase the enrollment from less than 200 to over 2000 represents the achievement of a master organizer. To serve without bias or prejudice, the opposing interests of manufacturers and users in the compilation of engineering standards, involved rugged honesty. And to carry on the tremendous detail of this organization meant great personal sacrifice, boundless enthusiasm, untiring zeal and energy. In Edgar Marburg was combined all of these attributes.

PERSONAL TRIBUTE BY WILLIAM EASBY, JR.

ABSTRACTED FROM ALUMNI REGISTER, UNIVERSITY OF PENNSYLVANIA, NOVEMBER, 1918.

Few have left a stronger impress of their personality on a life's work than has Edgar Marburg, for twenty-six years Professor-in-charge of the Department of Civil Engineering. Throughout this long period, covering years of devoted service, he gave unstintingly of the best that was in him towards the upbuilding of the department so wisely entrusted to his charge. That he was successful is well known and strikingly apparent to any who can compare the curriculum and facilities for instruction of a quarter of a century ago with those of the present.

Doctor Marburg's influence on engineering was far-reaching and salutary. It was strongly felt in his work as teacher, writer and executive throughout a wide and important circle of professional friends and acquaintances. It may truly be said that he supplied in himself, through his broad contact with the active side of engineering, a bond between his students and the professional life which they sought to enter. Though not himself a practicing engineer, he showed in his instruction the fullest appreciation of the value of practical illustration and acquaintance with business procedure. Through patient and sound advice he endeavored at all times to instill into the minds and hearts of his students a high regard for the dignity and worth of their chosen profession. The high standard of professional ethics which he set for them was but the expression of principles which he consistently observed throughout his professional life.

Doctor Marburg fully recognized and accepted the opportunities and obligations of his position as a teacher in a great institution of learning. With him teaching was not principally an occupation with a livelihood as its object, but a profession of the highest order which he knew to be far-reaching in its influence on the economic and social fabric of the country, worthy of that patient and devoted effort which he always bestowed upon it. His success as a teacher is unquestioned and followed naturally from the possession of those qualities which secure the respect, confidence and interest of students. He had to an unusual extent the faculty of divesting a subject of difficulties by exposing, through familiar and often homely illustrations, the fundamental thought involved and by arranging related matters with due regard to their importance. Recitations never lagged, were never tedious and unprofitable under the vitalizing influence of his strong nature. He felt the intellectual pulse of his classes and was quick to detect lack of comprehension. It was never too much trouble to extend instruction beyond the class-room to the earnest student in need of assistance.

In his intercourse with others, Doctor Marburg was always so sincere and direct that there could be no doubt about his views on any matter requiring an expression of opinion or about his action, were that required. His intellectual honesty was manifested in a constant effort to know the truth and to be guided by it. Quick and keen in his perception of essentials, he was at times seemingly impatient with the slower mental processes of others. In controversy he was alert, self-reliant, resourceful and a cogent reasoner, but not dogmatic nor ever unwilling to examine with open mind the well-considered views of others.

With his qualities of leadership he combined a loyal, sympathetic nature which found expression in quiet, unobtrusive service generously rendered with no thought of return and, in the last years of his life, often when overburdened with self-imposed tasks which seemed to lie in the path of duty.

PERSONAL TRIBUTE BY A. A. STEVENSON.

No doubt the members at large of the American Society for Testing Materials appreciate, in a certain measure, how much Doctor Marburg's connection with the Society had to do with its success. Those of us who, as officers of the Society and members of the Executive Committee during Doctor Marburg's tenure of office, had the privilege of working with him, can alone have a full realization of the extent to which his character as a man, with his ideas and ideals, independent of his work, had to do with the growth of the Society in influence and in numbers.

Any one working with the Doctor could not but have the greatest admiration for him. While at times one might have differed with him, there was never a question as to his motives, or a thought that he was prompted by any other motive than what, in his mind, was best for the Society. Doctor Marburg had at all times the interest of the Society at heart, and no one could have been more jealous of its good name. He would make any sacrifice and go to any length in working to advance its interest. His very enthusiasm and devotion led to overwork, and I have no doubt that this, in connection with his work at the University, was largely one of the causes that led to his untimely death in the prime of life. With it all, one could not but be impressed by the great modesty of the man. He was most bitterly opposed to anything that might seem like self-aggrandizement. It was the Society he thought of, and not himself. His desire was to see results; his greatest satisfaction, in work accomplished.

As an officer and member of the Executive Committee, I worked with Doctor Marburg seven years; saw a great deal of him; and had many conferences concerning the work and the future of the Society. The official relationship developed into a warm personal friendship that is, and always will be, one of my most cherished memories. His "Old man, how are you?" over the telephone or when we met, is sadly missed.

To me the most outstanding trait in Doctor Marburg's character was his sterling honesty. He was honest in his ideals, in his work, and in his life. What more fitting tribute could be paid to a man?

AMERICAN SOCIETY FOR TESTING MATERIALS.

ORGANIZED IN 1898.
INCORPORATED IN 1902.

PROCEEDINGS.

The Society is not responsible, as a body, for the statements and opinions advanced in this publication.

STANDARDIZATION.

ANNUAL ADDRESS BY THE PRESIDENT, GUILLIAM H. CLAMER.

JUNE 24, 1919.

INDUSTRIAL STANDARDIZATION AND INDUSTRIAL PROGRESS.

There was a time when the candle maker and the candlestick maker each made their wares to suit their own inclinations. As a consequence, seldom did the candle user find that the candle would fit his particular candle-stick. Time, in the days of candle illumination, was, however, not so precious as it is to-day, and a little more or less time consumed in shaving down its end, if the candle was too large, or if too small, in whittling a wedge to support its base, was of little consequence.

It nevertheless finally dawned upon these two classes of manufacturers that if they were to get together and standardize the size of the candles, and also make the sockets of their candlesticks of such dimensions that the candle would properly fit, time would be saved, annoyance prevented and convenience promoted. This is one of the early examples of standardization and it has been referred to by Sir Joseph Whitworth, one of the early workers in the field of standardization, and the introducer of the series of screw threads known as the Whitworth standard.

There was a time, not so long ago, when there was no United States standard track gage for our railroads. Without standardization of track gage it was impossible for the equipment of one railroad to be used on another. It has only been through standardization of track gage that interline transportation has been made possible. We now travel in the greatest comfort from one end of the country to the other without a change of cars. A freight car may be loaded in Maine and without transfer of its cargo arrive in San Francisco or Key West. In fact, it may even be loaded on a barge at Key West and transferred to any part of the Island of Cuba over United States standard-gage track.

At the present time very active progress is being made in railroad building in South America and Central America, and very shortly activities in the line of railroad building will be again resumed in Mexico; and it can be confidently expected that a Pan-American Railroad, extending from any part of the United States to Argentina, a distance of ten thousand miles, will become a reality. It is unfortunate, in this stupendous undertaking, that all sections of this railroad should not be of standard gage. A large part of the trackage in the Southern countries, as at present built and under contemplation, is of gage which differs from our own.

I do not believe that there is one single effort which can be taken in bringing countries of the Western Hemisphere into closer relationship than the building of a standard gage railroad over this entire distance.

There was a time, within the memory of the present generation, when there was no such thing as standard pipe sizes or threads; and, even more recently, when there were no standard machine screws. Each manufacturer had his own special threads. Selfish interests were so strong and the vision so narrow that great opposition on the part of the manufacturers prevailed against standardization of screw threads. Each manufacturer wished to compel the user of his machines to come to him for repair parts. He did not realize that his business interests were impaired if a user of his machine suffered inconvenience and perhaps financial loss by the shut-down of the machine because of the necessity of sending to the factory to get the necessary repair part.

There is at present before Congress a bill which proposes to extend the life of the commission to standardize screw threads, created under the act of July 18, 1918. Governmental action has in the past legalized other standards. The first attempt at standardization of screw threads, bolts, nuts, etc., was made in 1864 by a committee of the Franklin Institute of Philadelphia. This committee recommended the adoption of the system known as the United States Standard which was devised by William Sellers. In 1906 the Association of Licensed Automobile Manufacturers adopted standards for automobile screws and nuts, and a year later the American Society of Mechanical Engineers accepted the report of its committee on standard proportions for machine screws. The screw threads adopted by this society differ only in very minor details from the Sellers or U. S. Standard. This report specifies tolerances and includes standards for taps, special taps, special screws and screw-heads of various types. In 1912 the Society of Automobile Engineers enlarged their number of standards.

An Act of Congress in 1893 established a standard gaging system for sheet iron and steel. This was a purely arbitrary standard. Other arbitrary gages are in use for wire and drills as well as for sheets. The only rational system is the decimal system in which the gage number is expressed in thousandths of an unit.

There is a long list of further standardization work which has had its stimulating effect upon industrial progress, but these few illustrations I have given are sufficient to emphasize the importance and magnitude of this line of endeavor.

Only within the present century has standardization in manufacturing processes, methods and practice been seriously pursued and so-called scientific management inaugurated. Industrial progress owes much to the adoption of such standardization. In the automobile industry particularly we have outclassed the world because of such standardization. The adoption of standardization to shipbuilding during the war has put America, within two years time, in the first rank in this industry.

Quantity production can be realized only by reason of such standardization, and at the time of the signing of the Armistice, quantity production in the manufacture of our airplanes was well under way and history will no doubt reveal the fact that this was quite instrumental in bringing our enemies to the realization that it was futile to further pursue the war.

STANDARDIZATION WORK OF THE CONSERVATION DIVISION OF THE WAR INDUSTRIES BOARD.

During the war conservation of our resources became an absolute necessity and the work of the Conservation Division would have had far reaching effect had the war continued. The Conservation Division was organized to perform the function, which was expressed by the President in his letter to Mr. Baruch, as "the studious conservation of resources and facilities, by means of scientific, industrial and commercial economies, to meet war requirements."

The necessity for such standardization, as a war measure, was unquestioned, but just how far such standardization, in peace times, would be economically advantageous or economically detrimental, is speculative. Consumers are willing to pay for selection and for the gratification of their individualistic tastes as to style, color, form, etc. It is this fact which, in a very great measure, has resulted in the enormous number of commodities, differing in only slight degree from each other, now being offered on the market. A reference to but a few typical examples of our war-time conservation will be of interest in pointing out the wonderful possibilities in this direction.

Pneumatic tires, reduced from 232 styles to 9; solid rubber tires, 100 styles to 15; steel pens, 700 to 300; china and crockery, from 1696 pieces to 330; 5500 styles of rubber footwear discontinued, meaning a yearly saving as follows:

29 012 600	cartons,
5 245 300	sq. ft. of lumber,
4 795	tons of freight,
1 526 423	cu. ft. shipping and storage space,
2 250 272	lb. of material that will not have to be dyed,
74 750	lb. of flour and starch,
30 380	gallons of varnish,
125 300	lb. of tissue paper,
49 617	days of labor.

Consider such a matter as the method of packing thread. If marketed with 200 yd. to a spool, instead of 100 and 150, there would be saved 5,146,815 ft. of lumber or 365 carloads. The saving in shipping space of finished product is about 600 cars, in wrapping paper $3\frac{1}{2}$ tons, and in twine, 5 tons. Had the yardage been reduced to 100 yd. per spool it would have required over 600 cars to transport the lumber, so that the total saving is 1200 cars by using the 200-yd. spool.

With these few examples, it can be readily realized what tremendous savings might be effected if a safe and sane policy of standardization was put into effect through cooperative agreements. It means lower cost of production, smaller capital investment, etc., with a greater amount of capital released for more useful purposes.

RESEARCH AND ITS BEARING UPON STANDARDIZATION.

Emerson's definition of a standard is as follows: "That which is established by investigation or authority to be a reasonably attainable maximum of desirability."

Research and standardization should go hand in hand, but the body controlling the former should not also dominate the latter. Research should point out the ideal, namely, the highest standard of excellence which should be approached as nearly as possible by the approved standard. The final specification must of necessity be a compromise between consumer and producer, the consumer demanding the nearest approach to the ideal, and the producer agreeing to that which is commercially possible, cost, rapidity of production, service requirements, etc., all having due consideration.

Research bodies should never be satisfied that the ideal which they have set up is final, otherwise practice becomes crystallized and invention discouraged. What if the locomotive of twenty years ago, or even ten years ago, were to have been considered a final standard? What if the standard locomotive or standard cars recently adopted by the U. S. R. A. Committee were to be considered a final standard, or if the automobile of but a few years ago was no further improved upon? Such standardization, if not constantly open for revision, would, instead of benefiting the industries and mankind in general, actually do a positive harm.

Unfortunately, many standards have been adopted without a proper knowledge or without due consideration, and when such standards are once established it is exceedingly difficult, costly and inconvenient to abandon them. The one great shining example of this was the adoption of our cumbersome and unsatisfactory system of weights and measures.

When the great Niagara Falls Power Plant was to have been installed, expert opinion was secured to recommend whether direct or alternating current systems should be used. This was at a time when alternating current systems were quite new. Lord Kelvin, a great authority, recommended the installation of direct current apparatus. In the light of our present day knowledge on this subject, just think what a tremendous mistake that would have been. When it was finally decided to install alternating current, Professor Roland, of Johns Hopkins University, was consulted regarding the nature of the alternating current which should be used. After a painstaking investigation he recommended that current be delivered at 25 cycles. It, therefore, so happened that the expert advice that was followed in the installation of that plant resulted in the establishment of a standard for the current supply which has stood the test of time. In such an installation there is involved not only the power plant itself but all the existing circuits and equipments connected therewith, and it may therefore be realized how costly and inconvenient it would be to change, in a case of this kind, from one standard to another.

It frequently pays to adopt new standards, notwithstanding the expense involved, rather than to continue with an old standard which is evidently wrong and inefficient. Many examples exist in machine design, and in the standards adopted by the Master Car Builders' and Master Mechanics' Association and other standardizing bodies which are universally acknowledged as poor; but as the equipment has been built up about such standards and as to change would result in an enormous cost, they are unfortunately continued.

STANDARDIZED COST ACCOUNTING AND INDUSTRIAL COOPERATION.

Some time ago the New York milk dealers asked for an advance in the selling price of their commodity. They were unable to show the actual cost of milk delivered to the consumer and were therefore not in position to substantiate their demands. Investigation revealed the fact that adequate and reliable cost-keeping systems are rare. Some attempts have been made in certain industries to establish standard cost-keeping systems — the American Foundrymen's Association has a committee on the subject. They have retained an expert who acts in an advisory capacity to its members.

The cast-iron stove manufacturers have done the same. It was found that two manufacturers producing an identical line of stoves, exhibited widely different costs for the different types. A certain small type was sold by one manufacturer below the cost price of another, whereas, a larger type could not be produced by this same competitor at the latter manufacturer's selling price. The explanation is simple, namely, they used different methods for distributing costs.

With a standard cost-keeping system within an industry all would be benefited because all comparisons of the many items going to make up the cost would be upon an equal basis. A most important assistance could be rendered our industries if there should be organized a National Bureau for Establishing Cost Systems, the function of which should be to investigate the accounting systems in vogue in the industries, and to render assistance in the establishing of standard cost accounting.

During the war startling facts were revealed in this connection. The cost, as submitted by different manufacturers, on the same specification were so widely divergent that upon the "cost plus" basis the Government would have been called upon to pay widely varying prices for the same commodity. The need for standardization in this connection is so apparent that the United States Chamber of Commerce at a recent convention passed a resolution favoring a system of uniform cost accounting in each industry. This resolution had the endorsement of approximately 3000 men representing all lines of commercial and industrial interests, and emphasizes the growing desire and tendency of industrial leaders to do away with the rule of guess and gamble and to establish their industries upon the science of correct and adequate records and accounts. It is only by such means that the present day gross inefficiencies will become recognized and eliminated. True advancement in industrial management and operation can best come through industrial cooperation; it would be a pity to allow the fruits of the cooperation which was established during the war to be wasted now because of the throttling power of the now generally conceded unwise legislation which was enacted some years ago, namely, the so-called Anti-Trust Laws.

The value of industrial cooperation was well recognized and greatly encouraged by the Government during the war. Without such cooperation the wonderful productive capacity of our industrial establishments could not have been availed of to its fullest extent. Through standardized conditions, standardized records and standardized accounting, industries can be brought under intelligent Government supervision and control. It would thus only be possible for such cooperation to proceed and be encouraged without doing final harm to the public. In fact it would lead to the decided benefit of labor and of the public as well as to capital.

To emphasize the attitude of the present day in this connection, I will quote a resolution of the United States Chamber of Commerce, recently issued by that body which so strongly represents our American industries.

> "*Resolved:* The war has demonstrated that through industrial cooperation great economy may be achieved, waste eliminated and efficiency increased. The Nation should not forget, but rather should capitalize these lessons by adapting effective war practices to present conditions through permitting reasonable cooperation between units of industries under appropriate federal supervision. The conditions incident to the period of readjustment render imperative that all obstacles to reasonable cooperation be immediately removed through appropriate legislation."

INTERNATIONAL STANDARDIZATION.

Standardization is the keynote to convenience, comfort and efficiency. We are so accustomed to the use of our fundamental standards, weights and measures, expression in language, national currency, postage, etc., that we do not fully realize what the establishment of such standards means to us individually, and to our national prosperity. Were each state to have a different language, a different standard of weights and measures, etc., we would not now be united into a vast and prosperous country. There is nothing that will promote international trade cooperation and good fellowship so much as would the establishment of wise and mutually satisfactory standards, some of which may be classified as follows:

1. *International Language.*—National jealousies would no doubt prevent the adoption of any of the existing languages, unless the power of the nations now using such language should become sufficiently strong to enforce it. Germany, in her deep-seated plans to rule the world, had done all in her power to establish the German language in schools and colleges of many lands. Had her plans succeeded, the German language would no doubt have been enforced upon the world as it was in Alsace-Lorraine after the war of 1870.

The English language has long been the prevailing language in the world of commerce, and with the now still greater alliance of the Anglo-Saxon races will no doubt be extended. The English language as a standard leaves much to be desired when compared with the ideal; simplified spelling would help materially. The commercial advantages which would accrue temporarily (one generation at least) to the English speaking people of the earth, were the English language to become standardized, would be so great that such adoption would be sure to be frowned upon by all other nationalities. This being a fact, two entirely neutral languages have been proposed; these proposed languages being purely artificial, one known as Volapük, meaning "world speech," published in 1879, and the other Esperanti, named for its originator, proposed some years later.

The International Congress of Philosophy, which met in Paris in 1900, defined the following essentials with which such an artificial language must comply, namely:

The language shall serve the needs of daily life and business as well as the requirements of science and learning.

The language shall be so simple that a person possessing an average common school education can acquire it readily.

No doubt efforts will now be renewed toward the establishment of a standard system of expression for world-wide use.

2. *International Religion.*—Two hundred and sixty-eight

religious sects, past and present, are recorded. About one-third of the population of the globe are followers of Buddha. Many Christian denominations differ from one another mainly on interpretation of the Bible.

During the World's Columbian Exposition in Chicago in 1893, a Congress of Religions was held. It was attended by representatives of the Buddhists, Mohammedans and other Asiatic religions, as well as by all Christian denominations. No effort was made at that time toward the establishment of a Universal Religion, but the possibility of establishing such a religion has been much commented upon since that time, and especially since the beginning of the great world conflict, which was participated in mainly by the followers of the Christian religion, each of the contestants praying to the same God for victory.

The Utopian of yesterday is the commonplace of to-day, the dream of to-day is the reality of to-morrow. We are prone to forget that our own short life-time is but as a small fraction of a second in Eternity and we strive, in our imagination at least, to crowd into that small period of one generation the reforms for which the world will be ready for only many generations hence.

These two subjects for standardization, that I have just discussed, would hardly seem befitting in our present highly practical age, and especially before a Society which deals only with the strictly concrete subject of engineering materials. The standardization of language and religion is looked upon to-day as absolutely idealistic, but I feel very safe in predicting that in some future generation they will surely be a reality. I will now proceed with the more concrete subjects for standardization.

3. *International System of Weights and Measures.*—All are agreed that the Metric System is ideal. It is in use by every civilized nation with the exception of the United States and Great Britain and some of her colonial possessions. An association, having as its object the world-wide adoption of the Metric System, is in existence. This association, known as the Metric Association, is at the present time taking advantage of the world-wide desire for closer cooperation by carrying on a strong campaign for the adoption of the Metric System in England and in the United States.

The old German Osterling-Hanseatic League, which for hundreds of years controlled the trade of England, introduced the British pounds, both sterling and avoirdupois. We fell heir to these standards, which had been forced upon the British, through the British possession of a large part of the United States prior to the Revolutionary War.

It was James Watt, the eminent scientist of Great Britain, who invented a few years after the American Revolution, the decimal system of weights and measures now embodied in the Metric System. Unfortunately, we did not adopt the Watt System in the early days of our independent existence, neither did England adopt it notwithstanding the fact that it was a British invention. Germany, however, soon after the war of 1870 did adopt it. Germany, during its war with France, having acquired a closer familiarity with the decimal system, was brought to a realization of its superiority over their own system. The Metric System is referred to as the French system because of the French unit (the meter) employed.

To change from one system of weights and measures to another is no easy matter and it is exceedingly costly. The advantages, however, to be gained are so far reaching that the loss occasioned would be soon wiped out. We are to-day suffering because of the unfortunate choice and adoption years ago of a cumbersome system. To rid ourselves of this is analogous to taking a large dose of quinine, bitter and disagreeable, but nevertheless effective, with the patient better off for having taken it.

4. *International Standard of Temperature.*—How absurd is our Fahrenheit scale, and how confusing to have one scale for scientific expression and another for commercial usage.

5. *International Coinage System.*—Why not a system of coinage, as well as a system of weights and measures, based on the principle of the divisibility by ten?

6. *International Gaging System.*—How perfectly absurd are the various systems based upon numerals having no particular significance. The only scientific manner in which to express gage thicknesses for sheet, ire, cable, etc., is in the decimal system, using preferably the metric unit.

7. *Miscellaneous Standards.*—In addition to the above

standards, other standards such as screw threads, electrical rating, power rating, etc., can be internationally adopted. Already some progress in these directions has been made by the cooperation of the British Standards Committee and the American Society of Mechanical Engineers, American Institute of Electrical Engineers, and through other cooperative work.

8. *International Standards of Material.*—So long ago as 1898 there was organized in Philadelphia the American Section of the International Association for Testing Materials, which section was later incorporated as our present Society, which then became affiliated with the International Association for Testing Materials. Unfortunately, the International Association was opposed to the formation of international specifications for materials, and did not encourage the organization of strong national groups. It is questionable, if it is practicable or desirable, to revive the old International Association.

In this connection, at its quarterly meeting in April, your Executive Committee passed the following resolution:

> "*Resolved:* That the American Society for Testing Materials looks with favor upon the proposition of inquiring diligently whether an International Society for Engineering Materials can be formed to take up and broaden the work formerly done by the International Association for Testing Materials.
>
> "Dr. H. M. Howe, past-president of this Society, is going to Great Britain and France on a number of missions of a similar general nature, and we should be glad if the appropriate engineering bodies in those and other European countries would discuss with him, as our representative, the propriety of such a step and the means by which it might be brought about.
>
> "We believe that provision should be made for admitting the neutral countries into this organization.
>
> "We believe that the work of such an organization should be broader than was that of the International Association for Testing Materials, and that it should cover the development of knowledge of engineering materials and stimulate the science of testing materials, leading to the erection of international specifications as standards of reasonableness."

9. *International Standards of Testing.*—This is a matter which is of very great importance, and would logically come within the scope of the new International Society, if this becomes a reality.

It is to be hoped that through the World War the old "sores" established upon the principle of careful selfishness will have been largely eliminated, and through a League of Nations there shall be established a permanent basis upon which humanity may progress upon modern lines, leaving behind them the old prejudices and really establish a brotherhood of man, which may rest upon a permanent foundation having a realization that the human race is after all but one large family, and that national border lines are but of artificial creation.

STANDARDIZATION BODIES.

The work of standardization in this country has been more or less fragmentary. Such work has been undertaken by individual manufacturers, also by individual consumers, and by associations representing only producers and associations representing only consumers.

A great deal of creditable work has been done by the National Bureau of Standards and some work has been undertaken by the American Institute of Mechanical Engineers, although the Constitution of the latter society forbids the adoption of standards. This society, however, accepts its standard committee reports and sets its seal of approval upon the committee's recommendations.

A vast amount of work has been done by the Society of Automotive Engineers in the standardization of automobile parts and recently in aircraft parts. The Master Car Builders' Association and the Master Mechanics' Association have directed their efforts largely to standardization of railroad rolling equipment. The American Railway Engineering Association has devoted its attention primarily to railway subjects. The American Institute of Electrical Engineers and the Electric Power Club have undertaken much standardization work in connection with electrical equipment. Other standardization bodies are at work in various fields.

With the object in view of coordinating the standardization work of these various bodies to foster cooperation between all interested organizations and Government departments and to avoid duplication of effort, during the last year the American Engineering Standards Committee was organized. This committee was formed by joint action of five national Engineering Societies. Our Society, being one of that number, therefore became one of the founder societies which organized this committee.

The work of this committee had only about begun when action was taken toward greatly enlarging the size and scope of the committee as originally planned, and proposals were set forth and preliminary action taken to reorganize the committee into an American Engineering Standards Association embracing the subject of safety codes, fire protection, etc.

A considerable amount of discussion has been taking place, questioning if there is any added advantage in having the seal of approval of this committee placed upon the specifications presented to it. It is this function only which the American Engineering Standards Committee contemplated exercising, and this policy will no doubt also prevail if the committee is enlarged and organized as the American Engineering Standards Association. It is quite a serious question as to which is the better method: to grow slowly and conservatively, beginning with an amount of work which can be expected to be handled properly in a reasonable length of time, or to immediately attempt to handle the vast amount which has been more lately contemplated and in so doing incur the danger of at once becoming cumbersome and top-heavy. This is a problem which will remain for the interested societies to pass their judgment upon. Personally and unofficially, I feel that there is a real need and a real field for such a committee or association, and it but remains for the various details as to organization, policy and methods to be worked out and these should have most careful consideration.

I feel that the seal of approval of such a committee or association would give great weight and added recognition to a specification. I believe, however, that it would be a decided mistake for such a body to attempt to pass upon the substance of a specification, or to choose between two conflicting specifications covering the same subject which may be presented by two distinct standardizing bodies. No such specification should have the seal of approval unless the specification representing the joint action of such bodies be presented. All such standards, when finally adopted as American Standards, should be ever open for revision, otherwise practice will become crystallized.

National engineering bodies are in operation in England, Canada, France and Holland, and it can be confidently predicted that such bodies will be organized in other countries in the near future. Because of our present excellent and rapid means of communication, all the countries of the world are being brought in much closer relationship than ever before and in the immediate future there will begin an era of intermingling of the peoples of the various nations of the earth to a far greater extent than ever before, and it is therefore reasonable to assume that before many years have elapsed the needs of the world will demand international standardization to an ever increasing extent.

ANNUAL REPORT OF THE EXECUTIVE COMMITTEE.

Publications.—The regular publications issued last year are the largest in volume ever published in the history of the Society. A comparative statement as to the volume of regular publications during the past three years is exhibited in the following:

	1916–17 Pages.	1917–18 Pages.	1918–19 Pages.
Proceedings	1114	1550	1244
Book of A.S.T.M. Standards	752	....	908
Membership Pamphlet	229	251	297
Pamphlet of 4 new A.S.T.M. Standards adopted in 1917	...	41	....
Total	2095	1842	2449

In pursuance of action taken at the last annual meeting the Book of A.S.T.M. Standards is now issued triennially. The 1918 edition (908 pp.) contains the 128 standards adopted by the Society. Such proposed new standards as may be adopted by letter ballot following the annual meeting will be issued in a separate pamphlet of which every member will receive a copy.

In addition to the "regular publications" the Society has again published during the past year, in accordance with the policy adopted in 1917, a Book of A.S.T.M. Tentative Standards (298 pp.). The 49 Tentative Standards of the Society which appear in Part I of the Proceedings are published in this separate volume, which is placed on sale for the convenience of those desiring the tentative standards in a single book.

Thirteen circulars to members aggregating 54 pages have also been issued during the past year.

Membership.—The membership at the last annual meeting was 2261. Since then 391 applications for membership have been approved as compared with 269 during the previous year. The losses by death number 25, namely:

Charles Roy Adams	November 17, 1918
Bernt Berger	January 16, 1919
Owen Brainard	April 2, 1919

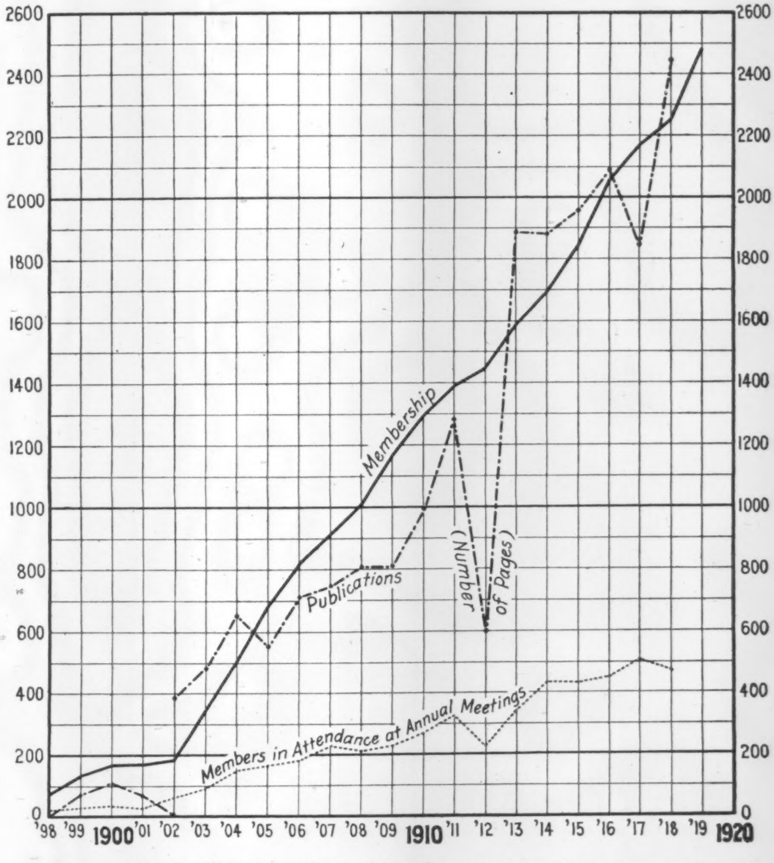
R. B. Carnahan	June 23, 1918
C. C. Crailie	June 17, 1918
John Sterling Deans	December 16, 1918
James Douglas	June 25, 1918
Roy O. Fitch	October 13, 1918
Arly L. Hedrick	March 5, 1919
Isidore Jaros	May 2, 1918
Joseph E. Johnson, Jr	April 4, 1919
William Kent	September 18, 1918
F. S. Leisenring	October 23, 1918
Thompson Lothrop	October 12, 1918
Edgar Marburg	June 27, 1918
A. P. Mills	October 20, 1918
John C. Mims	May 19, 1918
Benjamin Ogden	August 20, 1918
William R. Orr	April 26, 1919
Logan Waller Page	December 9, 1918
W. B. Reinke	November 1, 1918
J. D. Sinkinson	July 14, 1918
Raymond W. Smyth	September 27, 1918
L. A. Waterbury	June 15, 1918
Carrol Nathan Whitney	October 8, 1918

The number of resignations is 96 and 50 members have been dropped for non-payment of dues, the former being 6 less and the latter 13 less than for the previous year. The total losses for the year from all causes number 171, and the net increase in membership for the year is 220, as compared with 93 for the previous year, and with an average net annual increase of 137 for the preceding five years.

The Society is indeed to be congratulated upon this very substantial increase in membership during the past year, which it will be noted is in the ratio of approximately 5 to 2 compared with that for the previous year. Better evidence of the standing of the Society and of the appeal which its work makes to engineers and others interested in the broad subject of the materials of engineering could hardly be desired.

The total membership of the Society is now 2481, of whom 261 are Junior Members.

Standing Committees.—The activities of the standing committees during the past year have been most gratifying. Several committees whose members were nearly all engaged in war activities have found it possible since the armistice to do a



NOTE.—The initial curve for publications (1898–1902) refers to the publications of the American Section of the International Association for Testing Materials. The marked drop for 1912 in the "publications" and "members in attendance at annual meetings" curves is due to the fact that the Sixth Congress of the International Association was held in New York in September, 1912, and that the activities of the American Society for that year were accordingly restricted to committee reports and administrative business. The drop of the "publications" curve in 1917 is explained by the fact that the Book of A.S.T.M. Standards was not published that year.

considerable amount of work, and it may confidently be anticipated that with the return of normal conditions each committee in the Society will be able to turn its attention more actively than ever to the many important problems confronting it.

The volume and importance of the activities of the committees is evident from a summary given later in this report of the recommendations of the committees affecting standards. Among these will be found Specifications and Analyses covering several of the important Non-Ferrous Metals and Alloys; Specifications for Building Brick; Methods for Chemical Analysis of Lime; Methods for Tests of Refractories; Specifications for Gypsum and Gypsum Products, including Methods of Tests; Tests for Viscosity of Lubricants; Specifications for certain Road Materials; Specifications for Rubber Products, etc.

During the past year Committee E-7 on Classification of Technical Literature Concerning Materials has been discontinued pending the possible renewal, on return of normal conditions, of the activities of the Joint Committee on the Classification of Technical Literature, formed in 1915 of representatives from a considerable number of engineering and technical associations.

Committee C-7 on Lime was reorganized in the fall of 1918 and has since been very actively at work.

The reorganization of Committee C-10 on Hollow Building Tile, announced last year as under consideration by the Executive Committee, will, it is hoped, be shortly effected.

One new committee has been created to be known as Committee A-8 on Magnetic Analysis. As a most effective means of inaugurating the work of this committee, a Topical Discussion on Magnetic Analysis has been arranged for the present meeting in which a number of members of the committee will participate.

Recommendations of Standing Committees Affecting Standards.—The recommendations of the standing committees affecting standards are presented below in summarized form for convenience in obtaining a general oversight of the activities of the committees for the past year.

I. PROPOSED REVISIONS IN STANDARDS RECOMMENDED AS TENTATIVE.

Recommended by Committee A-1 on Steel:

For Open-hearth Steel Girder and High Tee Rails (A 2–12).

Recommended by Committee A-2 on Wrought Iron:

For Engine-Bolt Iron (A 40–18).

Recommended by Committee D-4 on Road Materials:

For Loss on Heating of Oil and Asphaltic Compounds (D 6–16).

Recommended by Committee D-11 on Rubber Products:

For $2\frac{5}{8}$-in. Cotton Rubber-Lined Fire Hose for Private Department Use (D 14–15);
For $2\frac{1}{2}$, 3 and $3\frac{1}{2}$-in. Double-Jacketed Cotton Rubber-Lined Hose for Public Fire Department Use (D 26–18).

II. TENTATIVE STANDARDS RECOMMENDED FOR ADOPTION AS STANDARD.

Recommended by Committee A-7 on Malleable Castings:

For Malleable Castings (A 75–18 T).

Recommended by Committee B-2 on Non-Ferrous Metals and Alloys:

For Cartridge Brass (B 19–18 T);
For Cartridge Brass Disks (B 20–18 T);
For Naval Brass Rods for Structural Purposes (B 21–18 T);
Methods for Chemical Analysis of Manganese Bronze (B 27–18 T);
Methods for Chemical Analysis of Gun Metal (B 28–18 T).

Recommended by Committee C-4 on Clay and Cement Sewer Pipe:

Recommended Practice for Laying Sewer Pipe (C 12–17 T).

Recommended by Committee D-1 on Preservative Coatings:

Test for Flash Point of Volatile Paint Thinners (D 28–18 T), as revised.

Recommended by Committee D-4 on Road Materials:

Tests for Determination of Apparent Specific Gravity of Sand, Stone and Slag Screenings and Other Fine Non-Bituminous Highway Materials (D 55–18 T);
Method for Determination of Softening Point of Bituminous Materials other than Tar Products (D 36–16 T), as revised.

III. PROPOSED NEW TENTATIVE STANDARDS.

Recommended by Committee A-1 on Steel:

For Plates for Forge Welding.

Recommended by Committee A-2 on Wrought Iron:

For Extra Refined Wrought-Iron Bars.

Recommended by Committee B-1 on Copper Wire:

For Tinned Soft or Annealed Copper Wire for Rubber Insulation.

Recommended by Committee B-2 on Non-Ferrous Metals and Alloys:

For Brass Ingot Metal for Sand Castings;
For Bronze Bearing Metal in Ingot Form;
For Lead;
For Solder Metal;
Method for Battery Assay of Copper;
Method for Chemical Analysis of Pig Lead.

Recommended by Committee C-3 on Brick:

For Building Brick.

Recommended by Committee C-7 on Lime:

Methods for Chemical Analysis of Limestone, Lime and Hydrated Lime.

Recommended by Committee C-8 on Refractories:

Test for Determination of Softening Point of Fire Clay Brick;
Definitions for Clay Refractories.

Recommended by Committee C-11 on Gypsum:

For Gypsum;
For Calcined Gypsum;
For Gypsum Plasters;
Method of Tests for Gypsum and Gypsum Products.

Recommended by Committee D-2 on Lubricants:

Test for Viscosity of Lubricants.

Recommended by Committee D-3 on Methods of Sampling and Analysis of Coal:

Methods for Determination of Fusibility of Coal Ash.

Recommended by Committee D-4 on Road Materials:

Method for Determination of Softening Point of Tar Products (Cube-in-Water Method);

For Materials for Cement Grout Filler for Brick and Stone Block Pavement;

For Materials for Cement Mortar Bed for Brick, Stone Block and Wood Block Pavement;

For Block for Granite Block Pavement.

Recommended by Committee D-11 on Rubber Products:

For Rubber Hose for Use with Pneumatic Tools;

For Adhesive Insulating Tape.

IV. PROPOSED REVISIONS IN TENTATIVE STANDARDS TO BE CONTINUED AS TENTATIVE.

Recommended by Committee B-2 on Non-Ferrous Metals and Alloys:

For Aluminum Ingots (B 24–18 T);

For Aluminum Sheet (B 25–18 T);

For Light Aluminum Casting Alloys (B 26–18 T)

Recommended by Committee C-7 on Lime:

For Masons' Hydrated Lime (C 6–17 T).

Recommended by Committee C-8 on Refractories:

Test for Slagging Action of Refractory Materials (C 17–17 T).

Recommended by Committee D-11 on Rubber Products:

For Rubber Belting for Power Transmission (D 53–18 T).

Recommended by Committee E-4 on Magnification Scales for Micrographs:

Definitions and Rules Governing the Preparation of Micrographs of Metals and Alloys (E 2–18 T).

Finances.—The finances of the Society, as may be seen from the following report of the auditors for the fiscal year January 1, 1918, to December 31, 1918, are in a favorable condition. From the comparison of the financial condition at the close of the five preceding fiscal years it will be seen that the surplus was increased during 1918 from $11,955.53 to $14,284.04, or an increase of $2,328.51.

REPORT OF AUDITORS FOR THE FISCAL YEAR JANUARY 1, 1918, TO DECEMBER 31, 1918.

JOHN HEINS AND CO.
PUBLIC ACCOUNTANTS AND AUDITORS.

PHILADELPHIA, January 6, 1919.

AMERICAN SOCIETY FOR TESTING MATERIALS,
MR. C. L. WARWICK, *Assistant Secretary,*
Philadelphia, Pa.

Dear Sirs:

We respectfully report that we have made an audit and examination of the books and accounts of your Society for the six months ended December 31, 1918; having previously made a similar audit and report for the preceding six months ended June 30, 1918, and at both audits found the accounts to be correct, and to be in their usual excellent condition.

We submit balance sheet as of December 31, 1918, as also a statement of cash receipts and disbursements for the twelve months then ended.

Respectfully submitted,
(Signed) JOHN HEINS AND CO.

BALANCE SHEET DECEMBER 31, 1918.

ASSETS.

Cash		$7,164.93	
Investment—$5000, 4¼ per cent U. S. Liberty bonds		4,880.63	
Accounts Receivable:			
Other than Members	$1,347.15		
Members for Publications	142.80		
Members for 1918 Dues	1,080.00		
		2,569.95	
			$14,615.51

LIABILITIES.

Accounts Payable		none	
Members dues paid in advance		$327.97	
Members binding paid in advance		3.50	
Life Membership	$1,300.00		
Surplus	12,984.04		
		14,284.04	
			$14,615.51

NOTE.—The stock of back publications and the office furniture are not appraised or included in this statement.

MISCELLANEOUS FUNDS.

In addition to the above cash the Secretary-Treasurer's office has on hand the following Funds:

Committee A-5 on Corrosion of Iron and Steel	$126.01	
Committee C-1 on Cement	4,841.79	
Committee C-9 on Concrete and Concrete Aggregates	609.19	
Committee C-10 on Hollow Building Tile	182.93	
Total, Committee Funds		$5,759.92
Edgar Marburg Memorial Scholarship Fund		$1,237.52

RECEIPTS AND DISBURSEMENTS.

JANUARY 1 TO DECEMBER 31, 1918.

Cash on hand January 1, 1918			$9,584.82

RECEIPTS.

Current dues	$31,039.85		
Past dues	518.05		
Advance dues	327.97		
		$31,885.87	
Binding (Members)		439.50	
Sale of Publications:			
Separate standards	$630.88		
Book of Standards, Proceedings, etc	5,508.12		
		6,139.00	
Sale of right to reprint standards		850.00	
Authors' reprints		133.84	
Sale of Certificates of Membership		31.50	
Interest on deposits		495.25	
Dues of members in military service refunded		82.50	
Miscellaneous		44.40	
Total receipts			40,101.86
			$49,686.68

DISBURSEMENTS.

Publications		$21,714.48
Salaries: Secretary-Treasurer	$2,700.00	
Assistant Secretary	2,150.00	
Regular clerical	4,064.00	
Extra clerical	956.00	
		9,870.00

DISBURSEMENTS (*Continued*).

Investment—$5000, 4¼ per cent U. S. Liberty bonds, Fourth Issue	$4,880.63	
Expenses, Delegate to International Aircraft Conference, London	1,865.03	
American Engineering Standards Committee	200.00	
Expenses, Standing Committees	692.55	
Expenses, Nominating Committee	134.32	
Traveling expenses, Executive Committee	256.60	
Expenses, Secretary-Treasurer's office	870.69	
Postage and expressage, Secretary-Treasurer's office	724.82	
Rent and Insurance, Storage room	220.50	
Auditing accounts	110.00	
Engrossing certificates of membership	20.25	
Stenographer, annual meeting	200.00	
Net expenses, annual meeting	608.28	
Refund of excess remittances	150.10	
Miscellaneous	3.50	
Total disbursements		$42,521.75
Cash on hand, December 31, 1918		$7,164.93

FINANCIAL CONDITION AT CLOSE OF FISCAL YEARS 1914–1918, INCLUSIVE.

Fiscal Year.	Assets.				Liabilities.	Deficit or Surplus.	
	Cash Balance.	Investment.	Accounts Receivable.	Total.	Accounts Payable.	Deficit.[a]	Surplus.[c]
1914	43.57	......	1044.74	1 088.31	6 421.27	5 332.96	......
1915	103.54	......	1 481.80	1 585.34	7 992.37	6 407.03	......
1916	845.78	......	2 595.24	3 441.02	300.93[b]	......	3 140.09
1917	9 584.82	......	2 601.71	12 186.53	231.00[b]	......	11 955.53
1918	7 164.93	4 880.63	2 569.95	14 615.51	331.47[b]	......	14 284.04

[a] This deficit includes a reserve for uncollected membership dues for the respective years of $765 and $813.

[b] These sums represent dues paid in advance and do not include any unpaid bills.

[c] These items include $1300.00 on account of Life Memberships.

Receipts from Sales of Publications.—The receipts from the sales of publications, $6139.00, are the largest ever reported and exceed the returns from this source last year by $555.59. The uniform increase in annual revenue from the sales of its publications is a gratifying barometer of the standing the Society has attained.

The receipts from the sales for one year of rights to reprint certain standards of the Society were as follows:

Carnegie Steel Company	$250.00
Portland Cement Association	250.00
Southern Pine Association	250.00
National Tube Company	100.00
Total	$850.00

Inventory of Publications in Stock.—In the foregoing financial analysis no account has been taken of the assets of the Society in the form of publications in stock. The inventory of the Proceedings on May 15, 1919, is as follows:

Volume.	Copies.	Volume.	Copies.	Volume.	Copies.
I	0	IX	508	XV, Part II	344
II	106	X	428	XVI, Part I	349
III	0	XI	385	XVI, Part II	353
IV	129	XII	125	XVII, Part I	240
V	302	XIII	449	XVII, Part II	231
VI	638	XIV, Part I	553	XVIII, Part I	301
VII	369	XIV, Part II	545	XVIII, Part II	337
VIII	381	XV, Part I	376		
				Total	7449

The stock of publications in general may be summarized as follows:

	Number of Copies.
Proceedings	7449
1918 Book of A.S.T.M. Standards	1060
Index (Vols. I–XII incl.)	725
Reports of Committee D-1 (1903–1914 incl.)	358

Proposed Amendment of the By-Laws.—The Executive Committee recommends the following changes in the by-laws:

ARTICLE I.—MEMBERS AND THEIR ELECTION.

Section 3: Amend this section to read as follows, by omitting the words in brackets and adding the words in italics:

> "A Junior Member shall be a person less than [thirty] *twenty-seven* years of age on the date of his admission, proposed by two members and elected by the Executive Committee.
>
> "A Junior Member shall have the same rights and privileges as a Member, except that he shall not be eligible for office, and his status shall be changed from that of Junior Member to Member at the beginning of the fiscal year next succeeding the date on which he attains the age of [thirty] *twenty-seven* years; *provided that a Junior Member holding membership at the date of adoption of this Section shall be continued under that status until the beginning of the fiscal year next succeeding the date on which he attains the age of thirty years.*"

ARTICLE II.—OFFICERS AND THEIR ELECTION.

Section 5: Amend the first sentence in this section as follows, by omitting the words in brackets and adding the words in italics:

> "The Secretary-Treasurer shall be elected annually by the Executive Committee at the first [meeting following the announcement of elections.] *quarterly meeting following the Annual Meeting of the Society.*"

In explanation of the proposed amendment by which the age limit of Junior Members is changed from thirty to twenty-seven years, the Executive Committee desires to state that Junior Members at dues of $7.50 per annum are carried at a very considerable financial loss to the Society, and it seemed desirable to minimize this loss as much as possible without, however, barring the advantages of membership in the Society to younger engineers to whom the full membership dues might be somewhat of a burden. It is believed that at the age of twenty-seven years, members of the Society are on the whole well able and willing to be advanced to the full status of Member and to pay the corresponding dues of $15.00.

It will be noted that the proposed amendment is not to apply to present Junior Members of the Society, who joined the Society with the understanding that they would be continued as such until they reached thirty years of age.

American Engineering Standards Committee.—In a Circular to Members issued in December, 1918, the Executive Committee announced to the membership that in pursuance of the favorable vote of the Society on the following resolution proposed at the last annual meeting:

> "*Resolved,* That the American Society for Testing Materials approves the scheme of organization of the proposed American Engineering Standards Committee, as outlined in the Constitution and Rules of Procedure submitted, and agrees to participate as a founder, as recommended by the Executive Committee.",

it had joined with the four Founder Societies in organizing the Standards Committee in October, 1918, and had appointed the following three representatives: Past-President A. A. Stevenson, Past-President A. W. Gibbs, and Mr. J. A. Capp.

In a later Circular issued in March, 1919, the Executive Committee advised the members of progress which had been made in the work of the Standards Committee since its organization, calling attention to the fact that two A.S.T.M. Standards, namely, Standard Specifications and Tests for Portland Cement (C 9–17) and Standard Specifications for Fire Tests for Materials of Construction (C 19–18) — selected for the wide cooperation which was had in their preparation — had been adopted by the committee as "Tentative Standards" with a view finally of their adoption as "American Standards," and that other standards of the Society were under consideration.

An important recommendation has been made by the Standards Committee to the member societies, namely, the desirability of publishing units of measurement in American Standards in both English and metric units. The Executive Committee has referred this recommendation to Committee E-5 on Standing Committees.

In the meantime the activities of the Standards Committee have been virtually suspended to afford opportunity for the consideration of important and far-reaching revisions in its Constitution providing means for admitting other technical bodies and government, state and municipal departments to direct representation on the Committee, in order better to secure their cooperation in carrying on its work. The proposed revised Constitution was adopted by the Standards Committee on May 17, 1919, and has only recently been referred to the governing boards of the member societies for approval. These proposed revisions materially alter the methods of organization of the Standards Committee and they will receive the careful consideration of the Executive Committee at its next meeting, which will be held during the annual meeting on the afternoon of Wednesday, June 26.

Editorial comments have appeared in the technical press relating to the activities of the Standards Committee, and in one instance pointing out the vital relation which those activities bear to the work of this Society. While the Executive Committee has taken careful note of the comments referred to, it has been considered best to defer any expression of opinion pending the consideration at its next meeting of the whole question of the reorganization of the Standards Committee.

Engineering Council.—As announced in a Circular to Members issued in March, 1919, the Executive Committee has accepted an invitation extended by the United Engineering Society to become a member of Engineering Council, which is an organization of national technical societies of America created under the auspices of the United Engineering Society "to provide for consideration of matters of common concern to Engineers as well as those of public welfare in which the Profession is interested, in order that united action may be made possible."

At present the member societies of Engineering Council are the four Founder Societies and the A. S. T. M. The Society, in proportion to its present membership, is entitled to one representative in Council, and the annual dues for one representative are $800. The representative of the Society on Engineering Council is Mr. Albert Ladd Colby.

One of the most important activities of Engineering Council is the maintenance of a National Service Committee with headquarters in the national capitol. The purposes of this committee are briefly:

> "1. To discover public services which may best be performed by engineering societies, and, when desired, to offer the proper men for such services.
>
> "2. To speak authoritatively for Engineering Council before committees of Congress and departments of Government on all public questions of common interest to engineers, within such limitations as Council may set from time to time.
>
> "3. To give promptly, wide circulation among engineers of authentic information regarding pending legislation and executive actions which may affect the interests of engineers in any way.
>
> "4. To gather opinions of engineers on these matters."

The chairman of the National Service Committee, Mr. M. O. Leighton, will address the Society at the opening session of the annual meeting on the activities of the committee. Important among these is the conference of engineering and related organizations which was held under its auspices in Chicago during the latter part of April for the purpose of considering the desirability of advocating the creation of a National Department of Public Works, as announced in a Circular to Members issued in May.

JOINT ACTIVITIES WITH OTHER SOCIETIES.

The constantly growing activities of the Society have resulted during the past year in cooperation with a number of other technical and scientific societies. The spirit of helpful cooperation among societies is being increasingly manifested in the consideration of engineering and industrial questions, and the Executive Committee has constantly endeavored to cooperate in every practicable way in the consideration of questions which fall within the field of activities of the Society. The importance of this cooperative work justifies, it is believed, the somewhat detailed statements which follow.

National Research Council.—In pursuance of an invitation extended by the National Research Council, Past-President

A. A. Stevenson has been appointed to represent the Society on the Engineering Division of the Council. In so far as the work of the Engineering Division relates to the preparation of engineering standards, it is believed that the Society can render important services in the coordination of its activities with those of the Engineering Division.

American Concrete Pipe Association.—The Executive Committee has appointed Mr. H. T. Shelley to represent the Society on the joint committee which has been formed by the American Concrete Pipe Association to consider specifications for Concrete Culvert Pipe. Other technical bodies represented on the joint committee are the American Concrete Institute, American Railway Engineering Association, American Society of Civil Engineers and American Association of State Highway Officials.

American Welding Society.—The members have doubtless noticed the announcement in the technical press of the organization of the American Welding Society to take over the activities of the Welding Committee of the American Institute of Electrical Engineers, following the withdrawal of financial support for the activities of that committee by the Emergency Fleet Corporation. With a view of directing cooperative research work and standardization in the field of welding, the American Bureau of Welding has been formed, consisting of the Board of Direction of the American Welding Society, which Society in effect will finance research work, and representatives of national technical societies and Government departments interested in the problem. The Society has accepted an invitation to be represented on the Bureau of Welding, and has appointed as its representative Mr. F. M. Farmer, who has long been active in the study of welding problems.

American Railway Engineering Association.—Upon an invitation from the American Railway Engineering Association, the Society through its Committee A-1 on Steel is cooperating with the A. R. E. A. Track Committee in the consideration of specifications for such track accessories as Splice Bars, Tie Plates, Track Bolts, etc. It is hoped that this cooperative work will result in the adoption by the two organizations of single standards of quality for these products.

Committee A-1 on Steel has announced its intention to give careful consideration during the coming year to the revision of the A.S.T.M. Specifications for Carbon-Steel Rails. The Rail Committee of the A. R. E. A. has similarly announced that it has under consideration the revision of A. R. E. A. rail specifications, and it has accordingly seemed most opportune for this important question to be jointly considered by the two organizations. The Executive Committee has therefore suggested to the American Railway Engineering Association its desire to cooperate in the revision of the rail specifications, and it is hoped that this extension of the cooperative work already instituted may be consummated during the coming year.

Specifications for Reinforced Concrete.—In its annual report last year the Executive Committee announced that it had been requested by Committee C-2 on Reinforced Concrete to invite certain other societies to cooperate with this Society in the preparation of Standard Specifications for Reinforced Concrete, and that it had determined to defer action on this request until it was prepared to adopt a definite policy on the general subject of the formation of joint committees with other societies, to which more detailed reference is made later in this report. While the time does not yet seem opportune for the Executive Committee to recommend definite regulations governing cooperative work, it has seemed desirable that the proposed cooperative work in this important field should not be longer delayed. Invitations have accordingly been extended to the following societies to join with this Society in forming a committee for the consideration of the subject:

American Society of Civil Engineers,
American Railway Engineering Association,
American Concrete Institute,
Portland Cement Association.

Aircraft Steels.—Committee A-1 on Steel has had under consideration during the past year the important question of the standardization of specifications for Aircraft Steels. It is desired, if possible, to work in cooperation with the Society of Automotive Engineers, and the Executive Committee has invited that Society to consider the formation of a joint committee on the subject.

In the latter part of May the United States Government invited a number of technical organizations, including the A. S. T. M., to appoint representatives on a National Technical Committee which would represent this country at an important Conference of the International Aircraft Standards Commission to be held in Paris during June. The Standards Commission was created in 1918 by representatives of the Allied countries, and it has seemed most important that this country be adequately represented in the consideration of technical questions at the Conference. The Executive Committee accordingly accepted the invitation of the Government and appointed Mr. J. A. Mathews as the representative of the Society. The National Committee was to have sailed early in June, but some uncertainty as to the legal right of the committee to represent the United States without an Act of Congress has made it necessary indefinitely to defer the date of sailing.

Standardization of Pattern Colors, Core Prints, etc.—At the suggestion of Mr. Richard Moldenke, Chairman of Committee A-3 on Cast Iron, the Executive Committee has considered the desirability of standardizing core prints, pattern colors, allowances in castings for position of holes, etc. It is believed that these questions primarily concern such technical bodies as the American Foundrymen's Association, Pattern Makers' Association and Steel Founders Society, and it has been determined to request one of these bodies to assume sponsorship for the subject, with the understanding that the Society will cooperate in so far as questions of materials may enter.

Resolution Relating to Joint Committee Work Referred to Executive Committee at 1917 Annual Meeting.—At the 1917 annual meeting of the Society the following resolution was adopted:

> "That the Executive Committee be requested to give consideration to the general subject of the formation of and methods of procedure to be followed by joint committees and the publication of joint reports; whether these joint committees be made up from various committees of this Society or of representatives of this Society and other societies and organizations."

In its report last year, the Executive Committee stated that it had concluded to defer action on this resolution pending developments in the work of the American Engineering Standards Committee, which was then in course of organization. It was expected that the methods of conducting cooperative work under this Committee would so develop during the year that the Executive Committee could draw up suitable regulations governing the joint activities of the Society with other organizations, which while they would not place any unnecessary restrictions upon the work of joint committees, would nevertheless define and protect the possibly divergent interests of the cooperating bodies. However, the proposed reorganization of the Standards Committee has left the question of cooperative work in such a state of flux that the Executive Committee has deemed it unwise to attempt to supply in the Regulations Governing Standing Committees the subject matter of the proposed Section 20 of those Regulations, covering "Regulations Governing Cooperative Relations."

On the other hand the need for cooperation with other societies has developed more strongly than ever before, and the Executive Committee has felt that it would not be justified in refraining entirely from the formation of joint committees pending the drawing up of explicit regulations governing their activities. It has therefore been determined, as will be evident from the preceding paragraphs of this report, to institute cooperative work where it seems most desirable. The Regulations Governing Standing Committees require (see Section 19) that "such cooperative relations shall entail no conditions at variance with these Regulations, and shall impose no restrictions upon the free and independent action of the standing committee." It is felt that under this broad regulation much valuable cooperative work can be started. The Executive Committee will therefore consider the conduct of such cooperative work in the light of conditions surrounding each particular instance, leaving until a more favorable opportunity the drafting of general regulations governing joint committees.

Translation of A.S.T.M. Standards into Spanish by the U. S. Department of Commerce.—The Executive Committee is pleased to announce that in pursuance of an agreement between the U. S. Department of Commerce and the Society, which has been referred to in previous annual reports of the Executive Committee, 62 standard specifications of the Society having an important bearing on the requirements of export trade have been printed in an English-Spanish edition and are being distributed among the U. S. Consular offices, particularly those in South American countries. These publications are part of an Industrial Standards Series issued by the Department of Commerce and may be purchased upon application to the Superintendent of Documents, Washington, D. C.

It is intended to begin as soon as possible the publication of A.S.T.M. Standards in an English-French edition under the same agreement.

Members in Military Service.—In its last annual report the Executive Committee announced the policy of suspending the dues of members who entered the active military service during the period of their service, such members retaining all privileges of membership including the receipt of publications. So far as known, the number of members in military service reached the total of 193. Since the signing of the armistice many members have returned to civil life. At present the records indicate that 128 are still in the service. The Executive Committee has ruled that members discharged from service prior to June 30, 1919, shall be liable for dues for the current year, and that members who continue in the service after June 30, 1919, shall have their dues remitted; but that members still in the service after January 1, 1920, shall thereafter be liable for dues.

Edgar Marburg Memorial Scholarship.—The members have already been advised through circular letters of the decision of the Executive Committee to honor the memory of its esteemed former Secretary-Treasurer, the late Dr. Edgar Marburg, by founding an Edgar Marburg Memorial Scholarship in the Department of Civil Engineering at the University of Pennsylvania, of which he was the Professor-in-charge for so many years of his life. Subscriptions from the members of the Society towards the necessary fund of $5000 to establish the scholarship are being received and the Scholarship will be formally presented to the University for award at the opening of the next college year.

Prospective Removal of Society Headquarters.—During the past year much consideration has been given by the Executive Committee to the desirability, if not necessity, of establishing separate headquarters commensurate with the dignity and standing to which the Society has attained. The maintenance of the headquarters of the Society in the Department of Civil Engineering at the University of Pennsylvania since its incorporation in 1902 has been, it is believed, most advantageous, and certainly every courtesy has been extended to the Society by the University; nevertheless, it would appear that the growth and increasing activities of the Society require an expansion which is not possible at the University.

A cordial invitation was extended to the Executive Committee to consider the establishment of Society headquarters in the Engineering Societies Building in New York City. After careful consideration, in which due weight was given to the much increased financial expense involved in the maintenance of headquarters in New York, it was decided that the best interests of the Society would be served by continuing its headquarters, at least for some time to come, in Philadelphia.

Accordingly, the Executive Committee has under consideration the establishment of headquarters in the building which now houses the Engineers' Club of Philadelphia, 1315 Spruce Street. The affiliation with the Engineers' Club of many of the local sections of national engineering and technical societies makes it the center of engineering activities in the Philadelphia district. It is hoped that preliminary negotiations which are now under way can be developed in time for consideration at the next meeting of the Executive Committee and definite report to the Society during the annual meeting.

Respectfully submitted on behalf of the Executive Committee,

GUILLIAM H. CLAMER,
President.

C. L. WARWICK,
Assistant Secretary.

EDITORIAL NOTE.

The proposed amendments to the By-laws referred to in the report of the Executive Committee (page 106) were adopted by letter ballot of the Society on September 1, 1919. The By-laws in their amended form appear on pages 11–18 of the 1919 Membership List.

APPENDIX.

EXCERPTS FROM MINUTES OF EXECUTIVE COMMITTEE.

REGULAR MEETING, June 26, 1918.—Hotel Traymore, Atlantic City, N. J. Present: Vice-President, S. S. Voorhees; Past-Presidents, A. W. Gibbs, A. A. Stevenson; Members of Executive Committee, W. H. Bassett, John Brunner, J. A. Capp, W. F. M. Goss, W. M. Kinney, G. W. Thompson, C. D. Young; Assistant to the Secretary, C. L. Warwick; and of the newly elected officers invited to attend: President-elect, G. H. Clamer; Members-elect of Executive Committee, G. Aertsen, G. B. Heckel.

The President-elect, Mr. G. H. Clamer, announced the appointment of the following members on the Finance Committee: Mr. G. Aertsen, Chairman; Mr. G. K. Burgess, and Mr. C. D. Young.

The Secretary-Treasurer reported that favorable action had been taken on 86 new applications for membership; 3 members had resigned, and that the Society had suffered the loss by death of one member; making the total membership in the Society on June 26, 1918, 2261.

Correspondence with the Director-General of Railroads was presented, in which it was revealed that upon further consideration the Director-General had reversed his original decision that memberships in the Society held by railroads should not be charged to operating expenses during Federal control, to the extent that "a single railroad under Federal control may purchase a single membership in its own name, designating the person who shall represent it in the Society. . . . . . The expenses of such membership may be charged to operating expenses." It was stated in that connection that the United States Railroad Administration, represented by the Department of Inspection and Tests, had recently acquired membership in the Society. It was the sense of the meeting that the Director-General should be requested to inform the Society as definitely as possible as to the names of the various railroads in Federal control which will be represented in the Society.

The Assistant to the Secretary reported the appointment by the President of Past-President A. A. Stevenson to membership on the Engineering Division of the National Research Council, as the representative of the Society, on the invitation of Mr. George E. Hale, Chairman of the Council.

The Assistant to the Secretary reported the acceptance by the Council of the American Society of Mechanical Engineers of the transfer to that body of the work of Committee E-3 on Revision of Pipe Threads, this proposal having already been approved by Committee E-3 and the Executive Committee.

A request was presented on behalf of Committee A-5 on Corrosion of Iron and Steel for the publication in the Proceedings, in connection with its annual report, of certain extensive tabular matter, at an estimated cost to the Society of $600. Voted that this expenditure be authorized.

A report to the Executive Committee was read from Mr. Albert Ladd Colby, the representative of the Society at an Anglo-American Aircraft Conference in London. Mr. Colby sailed on January 31 and returned on April 22. At the request of Major Diffin, Chairman of the American Commission, Mr. Colby drew up new aircraft steel specifications for presentation to the conference in place of certain specifications issued by the International Aircraft Standards Board. Mr. Colby's recommendations for the most part were accepted; a complete set of specifications were drafted in record time, accepted by the three British committees representing all interests and printed by the British Engineering Standards Association in pamphlet form (57 pp.) under the title "Specifications for Aircraft Steels for Government Purchases in the United States of America."

It was stated that Mr. Colby had deposited with the Secretary-Treasurer's office copies of the complete reports which he had prepared as well as a copy of the pamphlet referred to above; and that he expected to make a brief report of his activities in connection with the Conference to the Society at the fifth session of the annual meeting.

Voted that Mr. Colby's report be accepted; that a vote of thanks be extended to Mr. Colby for the very efficient services rendered in connection with the work of the Anglo-American Aircraft Conference; and that the Executive Committee desires to express its deep appreciation of the personal sacrifice made by Mr. Colby in order to act as the representative of the A. S. T. M. at the above Conference.

A communication was presented under date of June 18 from Mr. C. W. Burrows, recommending the creation of a new committee on Magnetic Analysis, and giving the names of 11 individuals actively engaged in this work as a nucleus for the proposed committee.

Voted that the creation of a new committee on Magnetic Analysis be authorized; that Mr. Burrows be appointed to the temporary chairmanship of the committee; and that the appointments on the committee be left with power to the President, the Secretary-Treasurer and Mr. Burrows.

A communication, under date of June 22, from Mr. George S. Pope, Chairman Committee D-5 on Coal, was presented, explaining that since the development and adoption in 1916 of the Standard Methods for Sampling of Coal, prepared by the committee "no material progress has been made in the further development of standard specifications for the reason that the purchase of coal under specifications has been in a continued state of evolution and development, and also that, as a result of the war, matters relating to the purchase of coal have been so abnormal and unsettled." The committee, however, requested its continuation for the reason that "there would thereby be immediately available, for any action that might be deemed wise after conditions become normal, the knowledge that the committee had acquired in its past work and the benefit of the experience had by its different members in their close relation to fuel progress, and there would be no lost motion in creating and organizing another committee."

Voted that the committee in its present organization be continued.

The Assistant to the Secretary called attention to the desirability of discontinuing Committee E-7 on Classification of Technical Literature Concerning Materials under the chairmanship of Mr. G. K. Burgess, inasmuch as this committee had been appointed to take care of the Society's interests in the Joint Committee on Classification of Technical Literature, and the latter had been discontinued as reported to the Executive Committee at its April meeting.

Voted that the committee be discontinued, subject to the approval of Mr. Burgess.

The Assistant to the Secretary reported at the request of Committee A-1 that Mr. Albert Ladd Colby, who had represented the Society at the recent Anglo-American Aircraft Conference in London, had advised that committee that he had been asked to act as American correspondent of the British Engineering Standards Association on the subject of Impact Testing, and that he desired to bring this to the attention of the committee for formal action; and that Committee A-1 had voted to refer the matter to the Executive Committee.

Voted that the request of the British Engineering Standards Association that Mr. Colby act as American correspondent on the subject of Impact Testing be referred to Committee E-1 on Methods of Testing; and that Committee E-1 be requested to report to the Executive Committee at its next quarterly meeting what action it has taken on this request.

A letter was presented under date of June 24 from Mr. A. D. Flinn, Secretary Engineering Council, advising that the American Society for Testing Materials had been elected to membership in Engineering Council subject to the approval of the governing bodies of the four founder societies. The Assistant to the Secretary stated that information concerning the ratification of this election may be expected in the fall.

Mr. Capp, one of the three representatives of the A. S. T. M. on the American Engineering Standards Organization Committee, presented as the report of the A. S. T. M. Committee, the Constitution and Rules of Procedure of the proposed American Engineering Standards Committee which had been adopted by unanimous vote of the Organization Committee on May 4, 1918.

This report contained a recommendation from the Organization Committee to the present five proposed founder societies that the Department of Commerce and the Army and Navy Departments be invited to join the committee with the standing of founders. It was explained that the Constitution and Rules of Procedure have been worded on the assumption that these Government departments will thus become members of the committee. Mr. Capp also presented, for the information of the Executive Committee, an abstract of the procedure under the proposed American Engineering Standards Committee.

After careful consideration and discussion it was voted:

1. That the Executive Committee approve the scheme of organization as proposed by the Organization Committee in the Constitution and Rules of Procedure, and recommends that it be referred to letter ballot of the Society.
2. That the Executive Committee approve the recommendation of the Organization Committee that the Department of Commerce and the Army

and Navy Departments be invited to join the committee with the standing of founders.

3. That the Executive Committee advise the Society in submitting this matter to letter ballot that it has voted that the appointments of the representatives of the A. S. T. M. on the American Engineering Standards Committee be made by the Executive Committee.

ADJOURNED MEETING, June 28, 1918.—Hotel Traymore, Atlantic City, N. J. Present: Vice-President, S. S. Voorhees; Past-President, A. A. Stevenson; Members of Executive Committee, J. A. Capp, W. M. Kinney; Members-elect of Executive Committee, G. Aertsen, G. B. Heckel.

Vice-President Voorhees stated that the purpose of the meeting was to take action on the death of the Secretary-Treasurer, Dr. Edgar Marburg, on June 27, 1918.

Voted that the chair appoint a committee of five, with power to enlarge its personnel, to draw up suitable resolutions, on behalf of the Executive Committee, on the death of the Secretary-Treasurer, and to present the same at the next meeting of the Executive Committee; this committee also to consider and report on an appropriate form of memorial meeting to be held in connection with the next annual meeting.

The Chairman appointed: President G. H. Clamer; Past-Presidents, W. H. Bixby and A. A. Stevenson; Mr. J. A. Capp, and the Assistant to the Secretary, Mr. C. L. Warwick.

It was decided that President Clamer, Past-President Stevenson, and the Assistant to the Secretary should consult with Provost Smith of the University of Pennsylvania in an endeavor to continue the present arrangements for conducting the business of the Society from the Engineering Building of that University.

The question of the election of a Secretary-Treasurer was informally discussed, and it was the sense of the meeting that inasmuch as the organization of the Secretary-Treasurer's office was such that the work of the Society would not suffer by a delay in making this appointment, it would be wise not to make an attempt to fill the vacancy at present, but to postpone such action, perhaps, until after the memorial session at the next annual meeting.

It was the sense of the meeting, following an extended discussion on the propriety of establishing an Edgar Marburg Memorial Fund, the income to be used for some specific purpose, perhaps the founding of a research scholarship, that this matter should be carefully considered and reported on by the committee of five referred to above.

REGULAR MEETING, October 17, 1918.—Engineers' Club, Philadelphia. Present: President, G. H. Clamer; Vice-President, George S. Webster; Past-President, A. A. Stevenson; Members of Executive Committee, G. Aertsen, G. K. Burgess, J. A. Capp, G. B. Heckel and W. M. Kinney; Assistant to the Secretary, C. L. Warwick.

The report of the tellers, Mr. I. B. Thomas and Mr. H. V. Wille, on the result of the letter ballot on (1) the amendment of the by-laws, (2) the resolution on the question of the participation of the Society in the organization of an American Engineering Standards Committee, (3) the adoption of proposed revisions in 21 standards, and (4) the adoption as standard of 28 tentative standards, as announced in Circular to Members No. 137 issued in September, was presented and formally accepted.

A discussion of an apparent inconsistency in the by-laws resulted in the adoption of a motion authorizing the President and Assistant Secretary to take the necessary steps to bring before the Society proposed amendments in the by-laws providing for the election of the Secretary-Treasurer at the October quarterly meeting of the Executive Committee.

The Assistant Secretary reported that favorable action had been taken on 83 new applications for membership; that 4 members had resigned; and that the Society had suffered the loss by death of 6 members; making the total membership in the Society on September 30, 1918, 2334.

The semi-annual report of the auditors was presented and ordered spread on the minutes:

JOHN HEINS & CO.,
Public Accountants and Auditors.

PHILADELPHIA. July 16, 1918.

AMERICAN SOCIETY FOR TESTING MATERIALS,
MR. C. L. WARWICK, *Assistant to the Secretary*,
Philadelphia, Pa.

Dear Sirs:

We respectfully report that we have made an audit and examination of the books and accounts of your Society for the six months ended June 30, 1918, and found the accounts to be correct, and to be in their usual excellent condition.

We submit balance sheet as of June 30, 1918; as also statement of cash receipts and disbursements for the six months then ended.

Respectfully submitted,
(Signed) JOHN HEINS & CO.

The President made a brief verbal report concerning a Convention of Building Industries at Atlantic City, July 15–16, which he attended as the representative of the Society on the invitation of the U. S. Chamber of Commerce.

The recommendation of Mr. W. M. Kinney that provision be made in the Regulations Governing Standing Committees "whereby it will be considered improper for non-producers to give their proxies for a committee meeting to producers or persons representing producing interests" was referred, on motion, to Committee E-5 on Standing Committees for consideration and report to the Executive Committee.

The Assistant Secretary reported the permanent organization of Committee A-8 on Magnetic Analysis under the chairmanship of Mr. C. W. Burrows. He stated that through the cooperation of this committee it would probably be possible to schedule a topical discussion on the subject of Magnetic Analysis for the next annual meeting.

The Assistant Secretary reported that the invitation extended by the British Engineering Standards Association to Mr. Albert Ladd Colby to act as their American correspondent on the subject of notched bar impact tests was referred to Committee E-1 on Methods of Testing for its recommendation, as directed at the last quarterly meeting of the Executive Committee; and that Mr. G. Lanza, Chairman of Committee E-1, recommends that the Society should cooperate with the British Engineering Standards Association in this matter through the sub-committee of Committee E-1 on Impact Tests, Mr. R. P. Devries, Chairman. The Assistant Secretary also presented a letter from Mr. Devries outlining the present and future activities of this sub-committee.

It was accordingly voted to cooperate with the British Engineering Standards Association on the subject of impact testing through Committee E-1 and its sub-committee on that subject, provided this is entirely agreeable to that Association.

In view of the favorable action by letter ballot of the Society on the proposed participation of the A. S. T. M. in the organization of an American Engineering Standards Committee, the following individuals were elected to represent the Society on that Committee:

Past-President A. A. Stevenson, to serve for one year;
Past-President A. W. Gibbs, to serve for two years;
Mr. J. A. Capp, to serve for three years.

A letter under date of October 9 from Mr. J. A. Capp to President Clamer was read, suggesting that the requirement in the Rules of Procedure of the American Engineering Standards Committee that a Sectional Committee shall consist of representatives of "producing, consuming and general interests," no one of these interests to form a majority, should be interpreted that the division of a Sectional Committee into producing, consuming and general interests shall be made at all times with respect to the specific standard under consideration.

The representatives of the Society were instructed to bring the subject matter of this communication to the notice of the American Engineering Standards Committee at its organization meeting, scheduled for October 19.

The special committee consisting of Messrs. Clamer, Bixby, Stevenson, Capp and Warwick on (*a*) Resolution of the Executive Committee on the death of Dr. Marburg; (*b*) Proposed Memorial Meeting, and (*c*) Proposed Memorial Fund, the income to be used for some specific purpose, such as the founding of a research scholarship, presented the following Minute on the death of Dr. Marburg:

In the death of Edgar Marburg, which occurred on June 27, 1918, the American Society for Testing Materials has suffered the irreparable loss of one of its most eminent and distinguished members; its executive officer since its incorporation; a leader in engineering thought and education and in the field of testing materials.

He was one of the small group which, in 1898, organized the American Section of the International Association for Testing Materials. In 1902 he was appointed acting secretary of the Section. He at once prepared for the Executive Committee a clear, comprehensive statement of the purposes of a testing society, as he conceived them, which led to the incorporation of the Society as an independent body. He was elected Secretary and Treasurer of the new Society, and to him was entrusted the executive direction of its affairs. From then till his death, a period of sixteen years, he worked assiduously for the success and advancement of the Society. He devoted much time and thought to the work of its technical committees and the standardization of specifications and methods of tests of the materials of engineering, and he shaped the policy under which these essential activities of the Society are conducted. The marked success which has attended the work and growth of the Society, and the interest and pleasures of its annual meetings, have been due in large part to his tireless and painstaking efforts. To his labors he brought great executive and organizing ability, excellent judgment, a clear grasp of the many and varied problems which confronted him, a sympathetic understanding of humanity, tremendous enthusiasm and zeal, and thoroughness in everything he undertook. His high ideals were reflected in every word and act. He was ever jealous of the good name of the Society, and sought throughout his leadership to extend its usefulness in every proper field.

To the officers and members of the Executive Committee, who were privileged to work intimately with him, his death brings a deep sense of personal loss and grief. His high integrity, his rugged honesty, his openmindedness, and his evident sincerity of purpose, endeared him to his associates, and commended their admiration, respect and devotion.

The character and personality of Edgar Marburg have indelibly impressed themselves upon the American Society for Testing Materials — an inspiration to the Society for all time.

On motion, the above Minute was adopted, and it was voted to have the Minute together with the Resolution adopted at the annual meeting suitably engrossed and presented to Mrs. Marburg.

The committee recommended that a Memorial Session commemorative of the life-work of Dr. Marburg be held in connection with the next annual meeting. On motion, it was voted to hold such a Memorial Session.

The committee also reported favorably on the proposed creation of an Edgar Marburg Memorial Fund, through the solicitation of subscriptions from the members of the Society, the income to be used in support of a scholarship in Civil Engineering at the University of Pennsylvania. Following a discussion of this subject, it was voted that the President and Assistant Secretary be authorized to circularize the membership of the Society in solicitation of contributions to such a fund and to call attention in that connection to the fact that in order to secure a sufficient sum for this purpose a minimum subscription of $2.50 per member would be necessary.

The Assistant Secretary presented correspondence with Mr. C. P. Van Gundy, Mr. P. H. Conradson and Mr. K. G. Mackenzie, Chairman, Vice-Chairman and Secretary, respectively, of Committee D-2 on Lubricants, relating to the form of title which shall be adopted for the Carbon Residue Test in the Standard Tests for Lubricants (D 47–18) recently adopted by letter ballot vote of the Society.

After careful consideration of every phase of the matter, as revealed by the correspondence, it was voted that the title of the Carbon Residue Test in the Standard Tests for Lubricants shall be published in the following form:

CARBON RESIDUE.
(CONRADSON METHOD.)

with the footnote now printed with the present title, namely:

" This method is a modification by P. H. Conradson of his original method and apparatus for Carbon Test and Ash Residue in Petroleum Lubrication

Oils. See *Proceedings*, Eighth International Congress of Applied Chemistry, New York, September, 1912, Vol. 1, p. 131. Also reprint in the Journal of Industrial and Engineering Chemistry, Vol. 4, No. 11, November, 1912."

REGULAR MEETING, January 14, 1919.—Engineering Societies Building, New York City. Present: President, G. H. Clamer; Vice-President, George S. Webster; Past-Presidents, Mansfield Merriman, A. A. Stevenson and W. H. Bixby; Members of Executive Committee, G. Aertsen, J. A. Capp, G. B. Heckel and K. W. Zimmerschied; Assistant Secretary, C. L. Warwick.

President Clamer and the Assistant Secretary, who had been charged with the preparation of certain amendments of the By-Laws, recommended the following amendment:

"Article II, Sec. 5 of the By-Laws. Change the first sentence from:

"The Secretary-Treasurer shall be elected annually by the Executive Committee at the first meeting following the announcement of elections."

to:

"The Secretary-Treasurer shall be elected annually by the Executive Committee at the first quarterly meeting following the annual meeting of the Society."

On motion, this proposed amendment was approved, with the understanding that its adoption by the Society will be recommended in the Annual Report of the Executive Committee.

The special committee consisting of Messrs. Clamer, Bixby, Stevenson, Capp and Warwick presented a tentative program for the Memorial Session at the next annual meeting on the life and life work of Edgar Marburg, which was approved.

Following a discussion as to the desirability of publishing a separate memorial volume, it was voted that in lieu of such a volume the Society should publish a memorial section to appear at the beginning of the volume containing the 1919 proceedings, which should also include a biographical sketch of Doctor Marburg.

The Assistant Secretary reported that favorable action has been taken on 52 new applications for membership; that 47 members had resigned; and that the Society had suffered a loss by death of 10 members; making the total membership in the Society on January 1, 1919, 2333.

The semi-annual report of the auditors was presented and ordered spread on the minutes:

JOHN HEINS & CO.
PUBLIC ACCOUNTANTS AND AUDITORS.

PHILADELPHIA, January 6, 1919.

AMERICAN SOCIETY FOR TESTING MATERIALS,
MR. C. L. WARWICK, *Assistant Secretary*,
Philadelphia, Pa.

Dear Sirs:

We respectfully report that we have made an audit and examination of the books and accounts of your Society for the six months ended December 31, 1918; having previously made a similar audit and report for the preceding six months ended June 30, 1918, and at both audits found the accounts to be correct, and to be in their usual excellent condition.

We submit balance sheet as of December 31, 1918, as also a statement of cash receipts and disbursements for the twelve months then ended.

Respectfully submitted,
(Signed) JOHN HEINS & CO.

Announcement was made of the formal organization, on October 19, 1918, of the American Engineering Standards Committee. The action of the President in authorizing a contribution of $200 towards the expenses of this Committee to December 31, 1918, was approved.

The Assistant Secretary stated that in pursuance of the following requirement in the Constitution of the Standards Committee:

> "As soon as possible after its organization the Main Committee shall make an estimate of its expenses for the first year and submit it to the governing bodies of the societies and Government departments represented on the Main Committee for their approval; such approval includes the pledge of each society and Government Department for such share as may be agreed upon."

that committee had adopted a budget amounting to $6000 for the year beginning January 1, 1919, and had referred it to the five societies now represented on the committees for approval.

Voted that the Executive Committee approve the budget of the American Engineering Standards Committee of $6000 for the year beginning January 1, 1919, and agrees to assume its share of these expenses pro rata with the other four societies represented on the committee, with the understanding that payments will be made by the five societies from time to time as needed.

On motion, Past-President Stevenson was authorized to bring before the American Engineering Standards Committee, at its meeting to be held on January 18, the question of having the secretaries of the five societies made members, ex-officio, of the committee without the privilege of voting, or, if that should not commend itself to the Committee, of having the secretaries invited to be present at the meetings of the Committee.

The report of tellers — Mr. George C. Davies and Mr. E. F. Kenney — on recommendations for appointments on the Nominating Committee for officers was presented in summary, the complete report being available in full detail for reference purposes.

Voted that, in addition to the last three Past-Presidents who are ex-officio members of the Nominating Committee, the following appointments on that committee be made, the "members" being those who have received the six highest votes:

Members	*Alternates*
Hughes, E. E.	Shuman, J. J.
McLeod, John	Morrow, J. G.
Kelley, F. W.	Boyer, E. D.
Bassett, W. H.	Campbell, William
Smith, H. E.	Young, J. B.
Abrams, D. A.	Porter, J. M.

The Assistant Secretary presented correspondence with the Hotel Traymore, Atlantic City, on the question of the 1919 annual meeting. It was voted that the annual meeting should be held at Atlantic City, with headquarters at the Hotel Traymore. It was agreed that the annual meeting should be held between June 15 and 30, and preferably from June 24 to 27, inclusive. The fixing of the exact dates was left with power to the President, with the understanding that the Assistant Secretary would immediately secure full information from the Hotel Traymore on the question of accommodations and possible conflict with the Master Mechanics' and Master Car Builders' Convention.

The Assistant Secretary reported that at the request of the President he attended a meeting of the Executive Committee of the Welding Committee of the A. I. E. E., at which it was explained that the Emergency Fleet Corporation intended to withdraw its financial support of the activities of the committee by the end of January. Steps are now under way to secure funds from the welding industry sufficient to continue the activities of the committee for three months, pending the formation of an American Welding Association which was fully discussed at the meeting. It is planned to have on the executive board of such an association representatives from Government departments and the national engineering societies. Certain articles of constitution were adopted and referred to a committee with instructions to prepare a Constitution and By-Laws for submission at a future meeting. When the American Welding Association has assumed more definite shape, the various Government Departments and national engineering societies, whose representation on the Board of Direction is desired, will be formally invited to consider the matter, and if favorably inclined to appoint a representative.

Past-President Stevenson announced the prospective founding of a Robert W. Hunt fund, the income to be used for a prize for the best paper or research on the subject of steel; the fund to be administered by a committee, consisting of two representatives each from the A. S. C. E., A. S. M. E., A. I. M. E., A. I. E. E., I. & S. INST. and A. S. T. M., without financial obligations on the part of those organizations. It was the sense of the Executive Committee that it would be desirable for the Society to be represented on this committee, and that an invitation to be so represented should receive favorable consideration on the part of the Executive Committee.

A discussion on the desirability of removing the headquarters of the Society to the Engineering Societies Building, New York City, resulted in a motion "authorizing the President to appoint a committee to investigate this matter and to report at the April meeting of the Executive Committee." The President announced the appointment on this committee of the Finance Committee, Messrs. Aertsen, Burgess and Young.

The Assistant Secretary presented a formal invitation from the United Engineering Society for the A. S. T. M. to become a member of Engineering Council, in the form of a letter under date of December 31 to President

Clamer from Mr. A. D. Flinn, Secretary, United Engineering Society and Engineering Council:

> "The Trustees of United Engineering Society hereby extend a cordial invitation to your Society to membership and representation in Engineering Council. . . . . .
>
> For your information we would say that the Societies of Civil, Mining, Mechanical and Electrical Engineers have each appropriated four thousand dollars per year for the uses of Engineering Council, total sixteen thousand dollars. Each has five representatives.
>
> The admission fee and dues of your Society, on the basis of your having less than 2500 members and therefore one representative on the Council, would be as follows:
>
>> Initiation fee, payable but once, $250. Assessment per representative for the full calendar year 1919 is $800; your assessment will be at this rate in equal monthly instalments for the portion of the year remaining after acceptance of membership.
>
> Upon accepting and completing the qualifications for membership in accordance with Rules for Admission of Additional Societies, American Society for Testing Materials will have all the rights, privileges and duties of an additional member society in Engineering Council, as stipulated in the By-Laws relating to Engineering Council and in the Rules.
>
> The Founder Societies and United Engineering Society will cordially welcome you to membership and will be pleased to have your aid in carrying forward the work of Engineering Council for the advancement of the engineering profession and for service to the Nation."

After an explanation of the work of Engineering Council and the responsibilities and privileges of membership thereon, it was voted that the Society accepts the invitation to membership on Engineering Council. The Assistant Secretary was instructed to advise Mr. Flinn of this action and to express the appreciation of the Executive Committee of the honor and compliment of being associated with the Founder Societies on Engineering Council, and to assure him that the Society will do all in its power to further the activities of the Council.

Mr. Aertsen, Chairman of the Finance Committee, called attention to the fact that at dues of $7.50 per annum, Junior Members were carried at a loss of approximately $9.00. On motion, the Assistant Secretary was directed to study the practice of other societies in the matter of Junior membership and to prepare, for the consideration of the Executive Committee at its next meeting, a proposed amendment of the by-laws reducing the present age limit for Junior Members from 30 to 25 years.

REGULAR MEETING, April 16, 1919.—Afternoon Session, Engineers' Club, Philadelphia; Evening Session, Union League, Philadelphia. Present: President, G. H. Clamer; Vice-President, George S. Webster; Past-President, A. A. Stevenson; Members of Executive Committee, G. Aertsen, G. K. Burgess, J. A. Capp, G. B. Heckel, and C. D. Young (afternoon session only); Assistant Secretary, C. L. Warwick.

Past-President A. N. Talbot was also present by invitation to present his views on the recommendation of Past-President Henry M. Howe, that the A. S. T. M. consider the desirability of undertaking the formation of an

International Society to take up and broaden the work formerly done by the International Association for Testing Materials. That subject was, therefore, immediately brought up for consideration. Communications were read from Mr. Howe, including proposed resolutions, and from Past-Presidents Merriman and Hunt. Following the discussion of this subject, the resolutions proposed by Mr. Howe, were somewhat amended and adopted in the following form:

"*Resolved*, That the American Society for Testing Materials looks with favor upon the proposition of inquiring diligently whether an International Society for Engineering Materials can be formed to take up and broaden the work formerly done by the International Association for Testing Materials.

"Mr. Henry M. Howe, Past-President of this Society, is going to Great Britain and France on a number of missions of a similar general nature, and we should be glad if the appropriate engineering bodies in those and other European countries would discuss with him as our representative, the propriety of such a step and the means by which it might be brought about."

"We believe that provision should be made for admitting the neutral countries into this organization."

"We believe that the work of such an organization should be broader than was that of the International Association for Testing Materials, and that it should cover the development of knowledge of engineering materials and stimulate the science of testing materials, leading to the erection of international specifications as standards of reasonableness."

It was also:

"Voted that Mr. Henry M. Howe, Past-President of the Society, be formally appointed as the representative of the Society to confer with the appropriate bodies in Great Britain, France and other European countries as to the propriety of bringing about the formation of an International Society for Engineering Materials, to take up and broaden the work formerly done by the International Association for Testing Materials, and the means by which such a step might be brought about; it being understood that the Society does not thereby incur any financial obligations."

The Assistant Secretary reported that favorable action had been taken on 115 new applications for membership; that 41 members had resigned; that the Society had suffered the loss by death of five members; and that 50 members had been dropped for non-payment of 1918 dues; making the total membership in the Society on March 31, 1919, 2352.

On the question of remission of dues of members in service, the Assistant Secretary stated that so far as known, 193 members had been in military service of whom 40, for various reasons, were not entitled to exemption from dues; 31 had advised the Society of their return to civil life, leaving 122 members on the records as still in service. He reported on the practice of other Societies, and submitted the following proposed letter to members still in service:

"By action of the Executive Committee, of which due announcement to the members of the Society was made late in 1917 and again in February, 1918, members who entered the active military service of the Government had their dues suspended during the period of such a service. Under this action no bills for dues for 1919 were mailed to those whose names were on our records as in military service on January 1, 1919.

It is presumed that many members have been honorably discharged since January 1. Some of these have so notified this office, but it is thought that others have inadvertently failed to do so.

You are accordingly requested to indicate your present status in this matter, using for that purpose the enclosed postal card."

It was voted that members discharged from service prior to June 30, 1919, should pay the full year's dues, and that members who continue in the service after June 30th should have the dues for the current year remitted; and further, that after January 1, 1920, no dues shall be remitted to members still in the military service.

The Assistant Secretary was directed to send the above letter to members still in service, supplemented by a statement of the action of the Executive Committee noted above.

In pursuance of instructions at the last meeting, the Assistant Secretary presented a detailed report on the practice of other societies in the matter of Junior Membership and an analysis of the A. S. T. M. Junior Membership. The latter indicated that the present junior membership (252) comprised about ten and a half per cent of the total membership (2352), and that the present junior members will have been carried as such for about five and a half years. Following a discussion of this subject, it was voted to change the age limit of junior members from 30 to 27 years and the President and Assistant Secretary were authorized to prepare the necessary change in the by-laws for submission to the Society. This action was taken with the understanding that it should not be retroactive.

The Assistant Secretary reported the receipt of a letter from Mr. C. B. Young, Inspection and Test Section, U. S. Railroad Administration, advising that the Railroad Administration had suggested to 33 railroads, not heretofore members of the Society, that they acquire membership. He stated that 13 of these had already joined and that it was expected that applications from the remaining 20 would be received in due course. He also reported that the total number of railroads holding membership is now 34, of which 10 have been acquired through the transfer of memberships formerly held personally by individuals, and that 14 other Roads were represented unofficially through individual memberships.

The Assistant Secretary reported on behalf of Committee E-5 on standing Committees that it had considered the question referred to it by the Executive Committee, whether the Regulations Governing Standing Committees should be amended to provide that it shall be improper for non-producers to delegate their proxies for committee meetings to producers or persons representing producing interests; and that Committee E-5 recommends that such a provision shall not be added to the Regulations basing its recommendations on the following considerations:

1. That committee members, either producers or non-producers, should retain the right to judge whether a certain individual is a proper person to represent him at a committee meeting.

2. That the Regulations in providing for numeric balance on committees between producers and non-producers do not intend that this balance shall necessarily be preserved at committee *meetings;* and, moreover, that the final

decision on all recommendations of committees is by letter ballot vote of the committee members themselves, in which the question of proxies has no influence;

3. That such a rule might be considered as a reflection on the integrity of committee members, and was therefore objectionable; and

4. That it would appear undesirable to make any further distinction in the Regulations between producers and non-producers than is absolutely necessary.

Voted that the recommendation of Committee E-5 be accepted and that the section on Proxies in the Regulations be retained as printed.

The Assistant Secretary reported that satisfactory progress was being made in the reorganization of Committee C-10, on Hollow Building Tile; that the Hollow Building Tile Association had voluntarily renewed its pledge of financial support and would subscribe the remaining $400 of the $600 originally promised; and that it had voted to take an active interest in future work of the committee. He stated that recommendations were expected shortly from the present chairman, Mr. L. H. Provine, as to the proposed personnel of the reorganized committee.

Voted to authorize the President and Assistant Secretary to act on Mr. Provine's recommendations when received.

The Assistant Secretary presented correspondence with Mr. Richard Moldenke, chairman of Committee A-3, relating to the proposed formation of a joint committee to standardize core prints, pattern colors, allowances in castings for position of holes, etc. It was explained that Mr. Moldenke had formed a joint committee consisting of representatives from several A. S. T. M. committees interested in castings and that the work of this committee was being held in abeyance, pending action by the Executive Committee on phases involving cooperation with other Societies which might seem to be more immediately concerned in this question.

After discussion of the question, it was the sense of the Executive Committee that it would be desirable to have from the beginning, the cooperation of other interested Societies. Voted that:

The Assistant Secretary be directed to bring this subject to the attention of the American Foundrymen's Association, the Patternmakers' Association, the Steel Founders' Society and the Division of Metals of the American Institute of Mining and Metallurgical Engineers, and to bring about, if possible, the formation of a Joint Committee on which these organizations would be represented, with the understanding that the Society wishes to cooperate in so far as materials are concerned.

The Assistant Secretary reported progress in the translation of A. S. T. M. Standards by the Department of Commerce, to the effect that 100 standards have been translated into Spanish of which 19 are printed, and 43 are in an advanced state of preparation for press.

He stated also that the Department was now in quest of a competent translator with a view of translating the Standards into French.

It was decided to appoint Mr. E. D. Boyer, chairman of the Entertainment Committee for the annual meeting, and to empower the committee to increase its number if desired. The Assistant Secretary was instructed to suggest to Mr. Boyer the desirability of the Entertainment Committee actively acting as a reception committee throughout the Convention and especially during the registration of members.

The report of the Nominating Committee for officers for the ensuing year was presented, which contained the following nominees who had all formally accepted their nomination:

For President, J. A. Capp;

For Vice-President, C. D. Young;

For Members of the Executive Committee, Ernest Ashton, C. F. W. Rys, Admiral D. W. Taylor and H. F. Moore.

The Assistant Secretary read an editorial which appeared in the February 27th issue of the Engineering News-Record suggesting to technical societies and individual engineers that they write to their congressmen in the interest of securing an appropriation so that the Bureau of Standards could continue certain concrete shear tests inaugurated by the Emergency Fleet Corporation. It was voted to refer this matter to Engineering Council.

Announcement was made of the reappointment by the President of Past-President A. A. Stevenson as the representative of the A. S. T. M. on the Engineering Division of the National Research Council.

An invitation was presented from the newly organized American Welding Society to appoint a delegate, without financial obligations, to serve with delegates of other national technical societies and Government departments on an American Bureau of Welding with a view of directing cooperative research work and standardization in the field of welding.

The Assistant Secretary stated that Mr. F. M. Farmer, Chief Engineer, Electrical Testing Laboratories, a member of the Society, was an active participant in this movement; that in response to his inquiry, Mr. Farmer had advised that he would be willing to act as the A. S. T. M. delegate in this Society; and that he had agreed to so act informally at a meeting held on April 11.

It was voted to appoint Mr. Farmer as the A. S. T. M. representative in the American Welding Society, and the Assistant Secretary was instructed to advise Mr. Farmer that in the judgment of the Executive Committee matters originating in the American Welding Society looking to the preparation of standards for materials should be referred to the A. S. T. M.

An invitation was presented from the American Concrete Pipe Association to appoint a representative on a joint committee to report on specifications for culvert pipe to consist of one representative each from the:

American Concrete Institute
American Railway Engineering Association
American Concrete Pipe Association
American Society of Civil Engineers
American Association of State Highway Officials
American Society for Testing Materials

It was voted to accept this invitation and to appoint Mr. H. T. Shelley, a member of Committee C-4.

Announcement was made of the appointment by the President of Past-Presidents Gibbs and Stevenson and the Assistant Secretary as a committee to confer with the officers of the Society of Automotive Engineers as to the possibilities of closer cooperation between the two organizations. Mr. Stevenson reported on behalf of the committee the substance of several conferences, particularly with reference to the subject of aircraft steels. On motion of Mr. Stevenson the committee was discharged.

Voted that a committee of three be appointed to confer with a like committee of the S. A. E. on the means by which a joint committee of the two societies can be formed for the purpose of preparing specifications for aircraft steels.

The President appointed Messrs. A. A. Stevenson, J. A. Capp and C. F. W. Rys on this committee.

For the information of the Executive Committee correspondence was presented between the President and Mr. Henry M. Howe relating to the functions of the Engineering Division of the National Research Council, in so far as they relate to the preparation of engineering standards, and suggesting the coordination of the functions of that Division, the A. S. T. M. and the Bureau of Standards.

It was agreed that no action was required and that the matter should be left in the hands of the President.

The Assistant Secretary presented a letter under date of January 9 from the Ordnance Department, U. S. A., bearing on the creation of a "Technical Division" in that Department and requesting the cooperation of the A. S. T. M. with that Division. Mr. Stevenson also presented correspondence on this subject. Following a discussion it was:

Voted that this matter be put in the hands of a committee consisting of the President, Past-President Stevenson and the Assistant Secretary with power to act.

The recommendation of Committee C-2 on Reinforced Concrete under date of August 16, 1917, that the American Society of Civil Engineers, American Railway Engineering Association, American Concrete Institute and the Portland Cement Association be invited to cooperate with Committee C-2 in the preparation of Standard Specifications for Reinforced Concrete, was then considered. The Assistant Secretary stated that this recommendation had been considered by the Executive Committee at meetings held in October 1917, and January, 1918, and at the latter was laid on the table pending developments in the organization of the American Engineering Standards Committee. He also read the explanatory note in that connection in Section 20, "Regulations Governing Cooperative Relations," in the Regulations Governing Standing Committees. After considerable discussion it was agreed to authorize this cooperation in accordance with the provisions of Section 19, "Methods of Initiating Cooperation," in the Regulations, and it was

Voted that Committee C-2 be informed that the Assistant Secretary will take the necessary steps to bring about the appointment of representatives of the four above-mentioned bodies to cooperate with a committee of the A. S. T. M. in the preparation of Specifications for Reinforced Concrete.

Voted that the formulation of Regulations Governing Cooperative Relations (Section 20 of the Regulations Governing Standing Committees) be deferred and that each case be handled when presented on its own merits.

Voted that the Assistant Secretary be instructed to make an explanatory note in the annual report of the Executive Committee as to why it was thought to be unwise to make fixed regulations at this time, and to revise the present explanatory note under Section 20 in the Regulations Governing Standing Committees accordingly.

The Assistant Secretary presented a letter from Mr. W. P. Wiltsee, chairman of the Track Committee of the A. R. E. A., requesting a conference with the A. S. T. M. committee on steel tie plates, wrought iron tie plates, malleable iron tie plates, track bolts, nut locks, cut track spikes and screw track spikes, with a view of agreeing on revised specifications.

Voted that Committee A-1 be authorized to appoint a committee to confer with the Track Committee of the A. R. E. A. in the above matters.

The Assistant Secretary called attention to the desirability of cooperating with the A. R. E. A. Rail Committee in the consideration of rail specifications, in view of the announced intention of that association to revise its specifications and in doing so consult with a committee of rail manufacturers.

Voted that the Assistant Secretary be authorized to communicate with the proper persons in the A. R. E. A. looking to the establishment of cooperative relations on rail matters.

The Assistant Secretary presented a letter from the Savings Division of the Treasury Department requesting the cooperation of the Society in the sale of War Savings Stamps. He was instructed to embody the letter in the last page of the next circular letter to members.

AMERICAN ENGINEERING STANDARDS COMMITTEE.

The following report of the A. S. T. M. representatives, Messrs. Capp, Gibbs and Stevenson, was presented by Mr. Capp:

"Since the last meeting of the Executive Committee there have been six meetings of the American Engineering Standards Committee as follows: January 18, February 1, March 1, March 15, March 29 and April 12. The principal question under consideration at these meetings has been the proposed reorganization of the Committee.

1. *Action on Certain A.S.T.M. Standards.*—Your representatives desired to place before the Standards Committee for action certain A.S.T.M. Specifications concerning which the most complete cooperation had obtained in their preparation. It was determined, therefore, to recommend for adoption as "Tentative Standard" the Standard Specifications and Tests for Portland Cement (C 9–17) and the Standard Specifications for Fire Tests of Materials and Construction (C 19–18). In presenting these specifications to the Committee, a complete history of each was submitted under the following headings:

(*a*) Data Relative to Preparation of the Specifications.
(*b*) Personnel of the Committee Responsible for them at the Time of Their Adoption or Last Revision, Divided into Producers and Non-Producers.

- (*c*) Results of the Letter Ballot Votes on Adoption as Standard or Last Revision, both of the Committee and of the Society.
- (*d*) Use of the Specifications by the Industry.
- (*e*) Possible Revisions now under Contemplation.

In preparing these statements, the assistance of the chairman of each of the two committees involved was obtained.

As a result of the recommendation of your representatives, these specifications have been duly adopted by a letter ballot vote of the Standards Committee as "Tentative Standard."

Your representatives have also prepared information along the above lines in connection with the five following standards:

Standard Specifications for Drain Tile (C 4–16);
Standard Tests for Toughness of Rock (D 3–18);
Standard Tests for Penetration of Bituminous Materials (D 5–16);
Standard Method for Distillation of Bituminous Materials Suitable for Road Treatment (D 20–18;)
Standard Method for Sampling of Coal (D 21–16).

These have been distributed among the members of the Standards Committee, but consideration thereon has been postponed in view of plans for reorganization.

It is recommended that the Executive Committee formally approve the action which has thus been taken by your representatives.

Similar information is being gathered in connection with certain steel specifications.

2. *Suggested Method of Procedure.*—Your representatives believe that a form of procedure should be adopted to be followed in bringing existing A.S.T.M. Standards before the Standards Committee. The following is suggested for the consideration of the Executive Committee:

- (*a*) To have the Secretary obtain the advice of the chairman of the committee responsible for a given standard, and to obtain his assistance in preparing a history of the standard along the lines outlined above.
- (*b*) This statement should then be submitted to the Executive Committee for them to decide and pass upon the submission of the standard to the Standards Committee. In this way your representatives would be presenting standards to the Standards Committee under definite instructions of the governing body of the Society.
- (*c*) Requests from the chairmen of committees that standards in their charge shall be submitted to the Standards Committee would be handled in the same way, the Secretary being authorized to proceed as in paragraph (*a*).

3. *Recommendation of Standards Committee.*—The Standards Committee has requested the sponsor societies, when submitting standards for their approval, to see that measurements in these standards be expressed in both English and metric units. Our Regulations Governing Form of Standards provide as follows:

> "Units of measurements shall be expressed in both the English and metric systems, if in the judgment of the committee concerned it is desirable to do so. Temperatures shall be expressed in Centigrade values, and also in Fahrenheit values, if in the judgment of the committee concerned it is desirable to do so."

Action taken:

Item 1. Approved.
Item 2. Voted that the President, Assistant Secretary, Representatives

of the A. S. T. M. on the Standards Committee and the chairmen of the A. S. T. M. committees concerned be constituted a standing committee, with power to act in so far as deciding which standards shall be submitted to the A. E. S. C. for adoption as American Standard or Tentative Standard; and that this committee shall report to the Executive Committee from time to time.

Item 3. Voted that this be referred to Committee E-5 on Standing Committees for their consideration and to report back to the Executive Committee; and that Committee E-5 be informed that in the judgment of the Executive Committee it is desirable to express both English and metric units.

Mr. Capp made a brief statement of conditions which have led the American Engineering Standards Committee to consider its reorganization along broader lines. He stated that the Standards Committee was preparing a revision of its Constitution for final action, first by the committee, and, second, by the governing boards of the five founder societies. It is expected that this proposed revision will be presented to the Executive Committee for action at its next quarterly meeting.

ENGINEERING COUNCIL.

The Assistant Secretary reported the appointment by the President, as previously announced by letter to the Executive Committee, of Mr. Albert Ladd Colby as the A. S. T. M. representative on Engineering Council.

The Assistant Secretary presented a letter from Mr. A. D. Flinn, Secretary, Engineering Council, from which the following is quoted:

> "After repeated consideration of the financial needs of the National Service Committee, Engineering Council at its regular meeting, February 20, 1919, adopted a budget for the Washington office for the calendar year 1919, amounting to $24,970, as reported in the minutes of that meeting. Chairman Channing, of Engineering Council, offered personally to guarantee the financing of the Washington office to an amount not in excess of $25,000. Mr. Channing's offer was accepted with appreciation, as it enabled Council to enter immediately upon the program laid out by the National Service Committee. It was
>
> "Voted that for the necessary support of the National Service Committe during 1919, Engineering Council ask from each Founder Society the sum of $5000, and from the American Society for Testing Materials an amount in like proportion to its membership. Engineering Council asks this with full knowledge of the difficulty which the grantor societies will neet in complying, but does so with the conviction that such money will be absolutely needed if the National Service Committee is to carry out the valuable work which has been started — work designed to increase respect for, and power of, the whole engineering profession."

The Assistant Secretary stated that the Society's share of the above budget would amount to about $1400.

Voted that after careful consideration of the above request of Engineering Council, the Executive Committee of the Society cannot see its way clear to comply therewith; and that the Assistant Secretary be directed to advise the Secretary of Engineering Council that the American Society for Testing Materials cannot grant the request of Engineering Council.

The Assistant Secretary presented an invitation from Engineering Council to appoint a delegate to a conference to be held in Chicago April 23-25 under the auspices of the National Service Committee to consider, primarily, the desirability of advocating the creation of a National Department of Public Works.

Voted that inasmuch as the subject to be considered, while of interest to engineers in general, is one with which the Society as such is not immediately concerned, in fact is really outside of the general field which the Society aims to cover, the Executive Committee deems it inadvisable to accept the invitation to send a delegate to the conference.

A letter was presented from the chairman of the National Service Committee *in re.* the distribution through the medium of monthly publications of the five societies in Engineering Council of circular matter on legislative and government matters prepared by that committee. In view of the fact that the Society does not publish a monthly journal and of other difficulties in carrying out this request it was

Voted that the Assistant Secretary be directed to advise the Chairman of the National Service Committee that it is impracticable for the Society to excerpt, print and distribute among its members the proposed circular matter on legislative and government questions prepared by that committee.

A communication from the Secretary of Engineering Council to the secretaries of the five member societies was presented, in which it was suggested that Mr. M. O. Leighton, Chairman, National Service Committee, be given an opportunity at the annual meeting to present a brief statement on the work of the National Service Committee. It was

Voted that such an opportunity should be granted to Mr. Leighton during the first session of the annual meeting.

Mr. Capp presented letters he had received from Mr. Albert Ladd Colby bearing on the aircraft steel situation. The Assistant Secretary was instructed to send a communication, on behalf of the Executive Committee, to Mr. C. Le Maistre, Secretary, British Engineering Standards Association, to the effect

"that a committe is in process of organization, to formulate specifications for Aircraft Steels; and assuming the willingness of the British Engineering Standards Association to cooperate with such a committee, the Executive Committee has the honor of inviting the British Engineering Standards Association to send representatives to this country to confer with this committee, when the work has progressed far enough to justify the calling of a joint meeting."

The report of the special committee (Finance Committee) appointed to report on the desirability of removing the headquarters of the Society to the Engineering Societies Building, New York City, copies of which had been mailed to the members of the Executive Committee on March 28, was then presented. After considerable discussion it was

Voted that the Assistant Secretary be instructed to advise Mr. Flinn, Secretary, United Engineering Society, that no decision regarding the proposed move to New York has been reached and that therefore the preliminary negotiations for rooms in the Engineering Societies Building cannot be carried further for the present.

The recommendation of the Finance Committee that the finances of the Society be conducted under the budget system was, on motion, approved. The budget for the year 1919, based on the maintenance of headquarters at the University of Pennsylvania, as submitted by the Finance Committee and mailed to members of the Executive Committee on April 9, was adopted.

ADJOURNED MEETING, May 1, 1919.—Union League, Philadelphia. Present: President, G. H. Clamer; Past-President, W. H. Bixby; Members of Executive Committee, G. Aertsen, G. K. Burgess, J. A. Capp, G. B. Heckel, C. D. Young; Assistant Secretary, C. L. Warwick; By invitation, Past-President, A. W. Gibbs.

The President announced that the purpose of the adjourned meeting was to give further consideration to several matters that had come up at the regular quarterly meeting held on April 16, the most important being the proposed removal of the headquarters of the Society from the University of Pennsylvania.

The President made a brief statement concerning the present arrangements with the University. He also stated that he had had an interview with the Provost to discuss the possibility of the A. S. T. M. continuing in the Civil Engineering Department, but that the Provost could not give any definite information because no action had as yet been taken with regard to Dr Marburg's successor.

On invitation of the President, the Assistant Secretary made a statement of his relations with the University. He referred to the constantly increasing amount of work involved in the secretaryship of the Society and expressed the opinion that the best interests of the Society called for a full-time secretary.

Genl. Bixby then presented a verbal report of the Proceedings at the Conference of Engineering Societies held in Chicago, April 23-25, under the auspices of the National Service Committee of Engineering Council, to consider the possibilities of creating a National Department of Public Works, which he attended as an informal representative of the Society. He also recited briefly the circumstances which led two years ago to the organization of Engineering Council.

The Assistant Secretary read the report of the special committee (Finance Committee) — presented at the regular quarterly meeting of the Executive Committee — which had been charged to report on the question of removing the headquarters of the Society to New York.

Following an extended discussion it was

Voted that the Secretary-Treasurer be placed on a full-time basis from and after the next annual meeting.

Voted that the A. S. T. M. shall not move to New York; and that the Finance Committee make the necessary preliminary arrangements — for report at the next quarterly meeting of the Executive Committee — for removing the headquarters of the Society from the University to another suitable location in Philadelphia.

The editorials in Engineering News-Record, issues of April 10 and 17, relating to Engineering Standardization and the interests of the A. S. T. M. therein, were considered. It was announced that an article by Mr. E. B. Rosa, of the Bureau of Standards, in part an answer to these editorials, would be published in Engineering News-Record in the issues of May 2 and 9.

It was the sense of the meeting that the replies which the President and other members of the Executive Committee had made to the editors of Engineering News-Record (not for publication) fully met the situation in so far as the Executive Committee was concerned, and that it was not necessary for a formal reply to be prepared by the Executive Committee. Rather it was the feeling that the Standards Committee itself must formally take cognizance of these editorial comments and Mr. Capp stated that he would see that the editorials were brought to the attention of the Standards Committee at its meeting on May 17 for suitable reply.

A communication from the Bureau of Standards transmitting the report of a Conference on Industrial Safety Codes, held at the Bureau on January 15, was presented, in which a number of societies including the A. S. T. M. were asked to vote on two plans of preparing industrial safety codes: Plan (A), by which such codes would be prepared by committees under the general direction of the Bureau of Standards; and Plan (B), by which codes would be prepared according to the procedure of the American Engineering Standards Committee, reorganized as outlined in the report.

On motion this communication was laid on the table with the understanding that the Assistant Secretary would inform the Bureau that the Society will not cast a vote in the matter.

REPORT OF COMMITTEE A-1

ON

STEEL.

During the past year Committee A-1 has held one meeting on March 7, 1919. A second meeting will be held prior to the presentation of this report to the Society, at which several important questions will be considered. The Advisory Committee has held two meetings at which matters concerning the general administrative affairs of the committee were considered.

The present membership of the committee is 123, of which 73 are classified as non-producers and 50 as producers.

Sub-Committees.—There have been no new sub-committees formed during the year, the total number being 17.

During the coming year the committee plans to organize a new Sub-Committee on Deep Drawing Steel Stock. In its annual report in 1917, the committee announced its intention of forming this sub-committee, but encountered such difficulties owing to war conditions that the matter was postponed.

The committee has under consideration the enlargement of the scope of activities of the present Sub-Committee XV on Cold-Drawn Steel to include specifications for hot rolled bars to be purchased to chemical composition. Recommendations will be received from Sub-Committee XV at the next meeting of the committee with regard to enlarged personnel and change of title to bring this about.

Administrative Affairs.—The committee has revised its regulations governing administrative work in two important particulars: first, by requiring its sub-committees to prepare their reports in such time that they can be distributed to the members of the committee sufficiently in advance of the meeting at which they are to be considered to allow of proper study; and second, by omitting the regular January meeting of the committee and requiring instead that the sub-committees shall hold regular meetings during that month with a view of preparing their final reports for the year for submission at the spring meeting of the committee, which has been moved forward from April to March. The latter change is made in pursuance of the wish of the Committee on Publications that committee reports shall be submitted as early in the year as possible.

It is believed that these changes will materially expedite the handling of the constantly growing affairs of the committee.

SPECIFICATIONS FOR AIRCRAFT STEELS.

The important question of specifications for aircraft steels has been under consideration for the past year. The committee is of the opinion that this work should be undertaken in cooperation with the Society of Automotive Engineers, which it is believed can best be done by the formation of a joint committee on aircraft steels. The committee accordingly recommended the formation of such a joint committee to the Executive Committee of the Society, which is undertaking negotiations to this end at the present time. By selecting a thoroughly representative personnel it is believed that such a joint committee will command the confidence of the American aircraft industry, and that questions of international standards for aircraft steels can be considered in an authoritative way.

NOTE PROVIDING FOR INCREASED PHOSPHORUS AND SULFUR LIMITS DURING THE WAR EMERGENCY.

One of the most important matters before the committee is the consideration of the nature of the recommendation which the committee shall make this year to the Society with regard to the note which was added to a number of steel specifications by action of the Society at the last annual meeting, reading as follows:

> "In view of the abnormal difficulty in obtaining materials in time of war, the rejection limits for sulfur in all steels and for phosphorus in acid steels shall be raised 0.01 per cent above the values given in these specifications. This shall be effective during the period of the war and until otherwise ordered by the Society."

As stated in the note itself, the reason for allowing this temporary modification in the phosphorus and sulfur requirements was the abnormal difficulty of obtaining materials in time of war that would meet the specified requirements of the Society's standards, owing to the higher phosphorus and sulfur content of the raw material which the unprecedented demand for steel forced manufacturers to use. The note, as stated, is "effective during the period of the war and until otherwise ordered by the Society."

At its meeting on March 7, the first which was held since the signing of the armistice, the sub-committees of Committee A-1 in charge of the specifications affected were instructed to submit recommendations to the committee with respect to the continuance or removal of the note, and to submit if possible with their recommendations such records of performance under the wider limits as may have been accumulated since the note became effective. The reports of these sub-committees, which will be considered at the next meeting of the committee just prior to the annual meeting, show such a wide divergence of opinion among the various sub-committees that the officers of the committee deemed it essential to take prompt steps to secure reliable data from both producers and consumers upon which the committee might base its judgment. A representative committee of producers and consumers has accordingly been appointed with instructions to collect all possible data bearing upon the following question:

> "Considering existing conditions with respect to raw materials, what date shall be set for the removal of the note from the several specifications to which it has applied?"

It is desired here to make it clear that the committee is at present considering simply the question of present industrial conditions in their bearing upon the date of removal of the note, as distinguished from the more general question as to whether the phosphorus and sulfur limits in the A.S.T.M. steel specifications are proper ones. The latter must be left to the careful study of the committee in the light of all available data. To that end the various sub-committees of Committee A-1 are under instructions to compile in so far as possible an adequate record of the service of material purchased under any of the committee's specifications which have been thus modified. There has not been time for such performance records to be made available and the committee is therefore in a position to consider only the specific question of the date of removal of the note.

This question will be carefully considered by the committee at its next meeting, and recommendations will be made to the Society when this report is presented.[1]

RECOMMENDATIONS AFFECTING STANDARDS.

The committee makes the following recommendations concerning standards:

Proposed Revision in Existing Standard.—The committee has prepared a proposed revision of the Standard Specifications for Open-hearth Steel Girder and High Tee Rails (A 2-12) given in detail below under the heading "Steel Rails and Accessories," by which the present drop test requirements would be replaced by a ball impression test. The committee recommends that this proposed revision be published as tentative. The result of the letter ballot vote of the committee on this recommendation is as follows: affirmative, 66; negative, 0; not voting, 42; total ballots cast, 108; 15 members failed to return their ballot; total membership, 123.

Proposed New Standard.—The committee has prepared proposed Tentative Specifications for Plates for Forge Welding which are appended to this report,[2] and to which detailed reference will be found in Appendix I. The committee recommends that these specifications be published as tentative. The result of the letter ballot vote of the committee on this recommendation is as follows: affirmative, 72; negative, 0; not voting, 36; total ballots cast, 108; 15 members failed to return their ballot; total membership, 123.

Recommendations Concerning Present Tentative Standards.—The committee is not prepared to recommend that any of the following five tentative specifications for which it is responsible be adopted as standard, and would accordingly ask that they be continued as tentative for another year without revision:

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[1] For the recommendations which Committee A-1 made to the Society with regard to the Phosphorus and Sulfur Note, and the action of the Society thereon, see Summary of the Proceedings, pp, 17–19.—ED.

[2] See pp. 448–453.—ED.

1. For Steel Tie Plates (A 67-18 T).
2. For Boiler and Firebox Steel for Stationary Service (A 70-18 T).
3. For Carbon Tool Steel (A 71-17 T).
4. For Low-Carbon Steel Track Bolts (A 76-18 T).
5. For Electric Cast Steel Anchor Chain (A 77-18 T).

In the following the committee presents a résumé of its activities during the year not previously mentioned, which is arranged for convenience in the order of the respective sub-committees concerned.

STEEL RAILS AND ACCESSORIES (SUB-COMMITTEE I).

Revisions in Girder Rail Specifications (A 2-12).—As announced by Committee A-1 in its last annual report,[1] Sub-Committee I has had under consideration, in cooperation with a committee of the American Electric Railway Association, the question of omitting the drop test in the Standard Specifications for Open-hearth Steel Girder and High Tee Rails (A 2-12)[2] and substituting therefor a ball impression test. The present specifications for girder rails call for a drop test similar to that used for standard T-rails. This test does not bring out the quality most desired by users of girder rails, namely, resistance to wear. In fact, its tendency is to discourage the use of the harder rail which is more resistant to wear. Moreover, girder rails, owing to their irregular section, are difficult to test in the drop, and their use in practice is such that the drop test is not considered to be an essential one as it is in the standard T-rail. To meet the demands of users of this material for an impression test to determine hardness, the committee has drawn up, in cooperation with the A. E. R. A. committee, the following requirements which it recommends be published as tentative by the Society with a view of adoption as standard when the specifications are next printed in the Book of A.S.T.M. Standards in 1921:

Omit Sections 7 to 10, inclusive, of the present specifications specifying drop test requirements, and substitute the following

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part I, p. 105 (1918).

[2] 1918 Book of A.S.T.M. Standards.

Sections 7 to 9, renumbering the remaining sections of the specifications:

Impression Test Specimens.

"7. (*a*) Four representative sections of rail from each melt shall be selected by the inspector as test specimens.

"(*b*) Excess scale on the head of the section shall be carefully removed.

Impression Test.

"8. (*a*) The head of each specimen shall be subjected to a pressure of 50 net tons (100,000 lb.) for a period of 15 seconds, applied through a ball $\frac{3}{4}$ in. in diameter.

"(*b*) The average depth of impression obtained on the four specimens shall not be more than 3.8 mm. for Class A rails, nor more than 3.6 mm. for Class B rails.

Retests.

"9. If the average of the impression tests from any melt fails to conform to the requirements specified in Section 8 (*b*), the manufacturer may at his option test each rail from such melt by making an impression test on the web, as described in Section 8 (*a*). Rails so tested which conform to the requirements as to depth of impression specified in Section 8 (*b*) shall be accepted."

The committee believes it is justified in recommending an impression test differing from the standard Brinell impression test, for several reasons: first, that the use of the larger ball is more convenient in view of the considerable number of tests contemplated (four from every melt, with provision for testing possibly every rail) and the size of the specimen; second, that the test is intended to be comparative simply in so far as girder rails are concerned, and not absolute—that is, that the user is not particularly interested in the Brinell hardness of the rail; and third, that the proposed test is in agreement with present foreign practice in tests of girder rails.

The proposed revision has been approved by the members of the A. E. R. A. committee with which Sub-Committee I has been cooperating, and it is understood that that committee will recommend its adoption by the American Electric Railway Association at the next meeting of that association.

Rail Specifications.—The committee intends to give careful consideration during the coming year to the revision of the A.S.T.M. Specifications for Carbon Steel Rails (A 1-14). The Rail Committee of the American Railway Engineering Association has under consideration certain revisions in the rail specifications of that association. Committee A-1 believes that it is most desirable to establish cooperative relations with the A. R. E. A. Rail Committee in the consideration of rail specifications, and on its recommendation the Executive Committee of the Society is instituting negotiations to that end.

Sub-Committee I has been in close touch with recent developments in the rail situation. In that connection it is of interest to note that there will be presented this year to the Society a paper dealing with "Deep Etching of Rails and Forgings," by F. M. Waring and K. E. Hofammann, which the committee hopes will be productive of much valuable discussion.

SPECIFICATIONS FOR PLATES FOR FORGE WELDING (SUB-COMMITTEE II).

In its annual report last year[1] the committee announced that it had under consideration the question of specifications for plates for forge welding. The report contained the recommendation that the Standard Specifications for Structural Steel for Cars (A 11-16) be revised to include requirements for plates for welding, but when the report was presented this recommendation was withdrawn for further consideration. The committee has decided that separate specifications for this product should be prepared, and tentative specifications are accordingly appended to the report.[2]

The considerations which have led to the requirements in the proposed specifications are so important that the report of Sub-Committee II presented to the committee in recommending the adoption of these specifications is given practically in full in Appendix I to this report.

SHIP STEEL (SUB-COMMITTEE III).

The committee will give consideration during the year to a matter which it was obliged to postpone during war activities, namely, the advisability of preparing a new table of permissible variations in ship plates ordered to weight per square foot with closer tolerances than those which now appear in the present specifications and with a limitation on undergage at the edge of the plates.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part I, pp. 105–106 (1918).

[2] See pp. 448–453.—ED.

STEEL CASTINGS (SUB-COMMITTEE VIII).

The committee has under consideration a revision of the Standard Specifications for Steel Castings (A 27-16) by which annealing lugs shall be placed on all important castings to aid the purchaser in judging of the quality of annealing. Tests which have been carried out on castings up to a maximum controlling thickness of 6 in. indicate that the appearance of the fracture of such test lugs when broken fully checks a careful microscopic survey of the structure of the castings. It would appear, however, that the fracture of the test lug becomes less indicative of the interior condition of the casting as the controlling thickness of the casting increases.

The committee is not yet prepared to propose this revision to the Society and intends to give the matter further consideration during the year.

TUBES AND PIPE (SUB-COMMITTEE IX).

A letter from one of the members of the Society, Mr. H. J. Skelton, of London, England, was referred to Committee A-1 and Committee A-2 on Wrought Iron, in which objection was made to the present practice in the Society's specifications for boiler tubes of indicating the thickness of tubes in decimals of an inch with the corresponding Birmingham wire gage number. Mr. Skelton suggested the use of either the Birmingham gage or the Standard wire gage established in England in 1914. The former is applied to wire and wire products and the latter to hoops, strips, sheet metal, etc. Upon consulting the Bureau of Standards it was learned that there is only one standard Birmingham wire gage in general use in this country, which is the one at present specified in the standards of the Society. It was accordingly determined to retain the use of that gage, but to recommend the following change in arrangement by which the headings in the tables of standard weights in the Specifications for Boiler Tubes for Locomotives (A 28-18) and the Specifications for Boiler Tubes for Stationary Service (A 52-18) will be changed from their present form:

Thickness.	
Inches.	B.w.g.

to read as follows:

Thickness, Birmingham Wire Gage.	
No.	Inches.

It is recommended that this change in arrangement of the headings be made in the specifications when the Book of Standards is next published in 1921.

The committee is also considering in cooperation with Committee A-2 a revision of the present Specifications of the Society for Steel Pipe (A 53-18) and for Wrought-Iron Pipe (A 72-18) by which the requirements of the specifications for both standard and extra strong pipe will be extended to include pipes up to 12 in. in diameter. The present specifications apply only to pipes 6 in. or under in diameter.

BOILER STEEL FOR STATIONARY SERVICE (SUB-COMMITTEE XI).

In its report last year[1] the committee proposed certain revisions distinguishing more sharply between flange and firebox steel in the Tentative Specifications for Boiler and Firebox Steel for Stationary Service (A 70-18 T) as the result of an agreement reached between the Boiler Code Committee of the American Society of Mechanical Engineers, the Association of Steel Manufacturers, and Committee A-1. The specifications in their revised form were then continued as tentative with the hope that they might be recommended for adoption as standard this year. There is, however, a question which the Boiler Code Committee still has under consideration, namely, the desirability of further distinguishing between the grades of flange and firebox steel by requiring a homogeneity test to be made from a broken bend test specimen for firebox steel, in addition to the homogeneity test now specified to be made from a broken tension test specimen. (Bend test specimens are taken transversely from the middle of the top of the plate, while tension test specimens are taken longitudinally from the bottom of the plate.)

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part I, pp. 131–132 (1918).

In view of the fact that this matter is still under joint consideration by the cooperating bodies referred to above, Committee A-1 believes it best to continue the present specifications as tentative for another year, which it accordingly recommends.

Ladle Test Ingot Investigations (Sub-Committee XII).

The committee desires to present the report of its Sub-Committee XII on the subject of Ladle Test Ingot Investigations which is attached to this report as Appendix II. The report contains a summary of the metallographic examination of medial and transverse sections, and the chemical examination of medial sections of four sets of ladle test ingots poured in five typical shapes of molds representing present practice.

The investigation has not been completed owing to the difficulties of carrying on the work during war conditions. It is hoped that it may be actively carried forward during the coming year.

Tool Steel (Sub-Committee XIV).

The committee has under consideration certain revisions in the present Tentative Specifications for Carbon Tool Steel (A 71-17 T), but is not yet prepared to make any definite recommendations to the Society. The committee accordingly asks that the present specifications be continued as tentative for another year.

Sub-Committee XIV in charge of specifications for tool steel has given consideration to the question of preparing specifications for high speed tool steel. It is believed that the time has not yet arrived to undertake the development of such specifications. A study and discussion of the subject is needed, and the committee hopes that the paper on Modern High Speed Steel to be read at the approaching annual meeting by John A. Mathews will result in helpful discussion.

Cast Steel Anchor Chain (Sub-Committee XVI).

Last year Committee A-1 recommended the adoption as tentative of Specifications for Electric Cast Steel Anchor Chain.[1] During the year several questions relating to these specifications have been under consideration by Sub-Committee XVI on Cast Steel Anchor Chain, namely:

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part I, p. 460 (1918).

1. The inclusion of chemical limits for phosphorus and sulfur;
2. The inclusion of shock test requirements;
3. The inclusion of tolerances on chain link dimensions.

The following recommendations of the sub-committee have been endorsed by Committee A-1:

1. *Chemical Requirements.*—A sub-sub-committee was appointed to investigate the question of specifying chemical requirements, particularly with reference to limits on phosphorus and sulfur; and if it is decided that such limits should be included the sub-sub-committee is to make definite recommendations as to what these limits should be.

2. *Shock Tests.*—It was the consensus of opinion of the sub-committee that this subject should be given further consideration, and that the sub-committee should have the opportunity of considering data that are now being accumulated by a sub-sub-committee before it will be in a position to make recommendations to Committee A-1.

3. *Tolerances on Dimensions.*—It was voted that Section 3 in the present specifications remain as now printed. It was brought out in the discussion that it would hardly be practicable to include a table of tolerances on dimensions that would satisfy all users on account of the variety in the sizes of anchor chain and the different requirements of the several classification societies.

The committee accordingly recommends that these specifications be continued as tentative without revision.

MISCELLANEOUS MATTERS.

Conservation of Manganese.—In October, 1918, the committee was requested by the Engineering Division of the National Research Council to assist it in its endeavor to reduce importation of manganese ore into this country in every way possible, and urged that the committee take such steps as it could to lower the manganese requirements in its steel specifications. There are 19 specifications of the Society which specify minimum manganese limits. A committee was accordingly appointed with instructions to consider, in the light of a war emergency measure, the possibilities of lowering or eliminating entirely the minimum manganese limits in these specifications. This committee began a thorough canvass of the situation, in the midst of which the armistice was signed, and as a result of subsequent correspondence with the National Research Council the request for special action was withdrawn.

The committee nevertheless completed its investigation of the matter among the various sub-committees in charge of these specifications, and the information which it obtained is on file with Committee A-1 for future reference if desired.

Specifications for Aluminum Shot for Use in Open-hearth Steel Practice.—During the year one of the members of the Society suggested the preparation of specifications for aluminum shot for use in open-hearth steel practice. Since the consideration of such specifications belongs properly to Committee B-2 on Non-Ferrous Metals and Alloys, Committee A-1 has consulted with Committee B-2, with the result that the question has been referred to its Sub-Committee VIII on Aluminum Alloys, Cast and Wrought, which will cooperate with a special committee to be appointed by Committee A-1. Any suggestions from members of the Society will be appreciated and should be directed to Mr. Jesse L. Jones, 198 Dewey Avenue, Edgewood Park, Pa.

Color Scheme for Marking Bar Steels.—The committee was asked during the year to take up the standardization of a color scheme for marking bar steels to distinguish the various grades. After careful consideration it was deemed impracticable to prepare such a standard color scheme.

This report has been submitted to letter ballot of the committee, which consists of 120 members, of whom 114 have voted affirmatively, none negatively, and 6 have refrained from voting.

Respectfully submitted on behalf of the committee,

J. A. CAPP,
Chairman.

C. L. WARWICK,
Secretary.

For Addendum to this report, see page 171.—ED.

APPENDIX I.

REPORT OF SUB-COMMITTEE II

ON

SPECIFICATIONS FOR PLATES FOR FORGE WELDING.

For the information of the members of the Society, the following memorandum is given explaining the origin and subsequent development of proposed standard specifications for plates for forge welding for tank cars and similar containers.

The chairman of the Tank Car Committee of the Master Car Builders' Association, Mr. A. W. Gibbs, requested Committee A-1 to issue a specification for forge-welding plates suitable especially for tank cars. This matter was referred to Sub-Committee II and initial work taken up with particular reference to that part of the M.C.B. Specifications for Tank Cars which reads as follows:

CLASS V—TANK CAR.

EFFECTIVE JANUARY 1, 1918.

Designs for this class of car, including details, the approval of which is specifically required, shall be submitted to and approved by the Master Car Builders' Association.

TANK.

> (*Note*:—It is so vitally important, because of the character of the commodities to be shipped in these cars, that the tank shall be absolutely tight, that riveted tanks will not be permitted, and all seams shall be welded.)

1. *Bursting Pressure.*—The calculated bursting pressure, based on the lowest tensile strength of the plate, shall be not less than 960 lb. per sq. in.

2. *Material.*—(*a*) All plates for tank, and for dome if dome is made of plate, shall be of steel complying with the American Society for Testing Materials Specifications for Boiler Plate Steel, Flange Quality. For the purpose of welding, the lowest carbon content consistent with the strength prescribed for this quality is desired.

The requirements of the A.S.T.M. Specifications for Boiler Steel, Flange Quality (Serial Designation: A 30-18) are:

Chemical Composition.

Carbon, per cent		....
Manganese, per cent		0.30–0.60
Phosphorus, per cent	Acid	not over 0.05
	Basic	" " 0.04
Sulfur, per cent		" " 0.05

No increase allowed for check analysis.

Physical Properties.

Tensile strength, lb. per sq. in.	55 000 – 65 000
Yield point, " "	0.5 tens. str.
Elongation in 8 in., per cent	$\frac{1\ 500\ 000}{\text{Tens. str.}}$

Reduction in elongation allowed for increased thickness.

There apparently was some objection on the part of the fabricators to using steel of such high tensile strength for welding; hence it was proposed that a softer grade should be specified, and that the A.S.T.M. should prepare a specification written especially for forge-welding plates.

Sub-Committee II considered this subject at two meetings held during last year. It was the intention, if possible, to reach a definite conclusion regarding the issue of a new standard specification for plates for forge welding and have it printed in the 1918 Book of A.S.T.M. Standards. The time was too short to accomplish this before the annual meeting last year. Therefore, the sub-committee recommended to Committee A-1 that requirements for plates for forge welding be incorporated in the Standard Specifications for Structural Steel for Cars (A 11-16), as indicated in the last annual report of the committee,[1] and referred to letter ballot for adoption as standard. It then developed that these requirements were not entirely satisfactory to the welding companies which use these plates. The matter was accordingly reconsidered by Committee A-1 at its June (1918) meeting, and the recommendation withdrawn before the report of the committee was presented.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part I, pp. 105 and 124 (1918).

It was decided by the committee at that meeting that separate specifications for plates for forge welding should be written. Accordingly, at a meeting of the sub-committee held January 10, 1919, at which 10 of a possible 18 members were present, information gathered from all available sources was considered. To determine the quality and grade of steel best suited for the use intended, both as to strength and weldability, the sub-committee obtained information from the Tank Car Committee of the Master Car Builders' Association, from the railroad companies who use the tank cars, and from the leading manufacturers in the country who are engaged in fabrication of tanks for cars by the forge-welding process. Based upon this information, the sub-committee prepared the attached Specifications for Plates for Forge Welding, which it recommends be adopted as tentative.

The following notes with respect to chemical and physical properties are given:

Chemical Composition.—All parties at interest seem to be agreed that carbon becomes a deterrent to good welding when in excess of 0.18 per cent. To encourage the narrowing of the working limits at the mills, it was determined to fix the chemical limits as "check analysis limits," without the 25 per cent excess allowance in the Specifications for Structural Steel for Cars. The sulfur limit was then placed at 0.05 per cent, which is somewhat closer than 0.045 per cent with 25 per cent excess on check analysis allowed in the revisions presented last year.

The consensus of opinion is that copper should be left out of the specifications. Limits for silicon, nickel and chromium have been set at 0.05 per cent for each element.

Physical Properties.—The sub-committee was advised by Mr. Gibbs that "the question of tensile strength is subordinate to that of the welding qualities, for if the chemistry required involves low tensile strength, the specified bursting strength can be obtained by increasing the thickness of the plate." The opinion seems to be unanimous that a soft steel is necessary, the general aim being for a carbon content of from 0.08 to 0.12 per cent for satisfactory welding properties. Having fixed the maximum carbon at 0.18 per cent, and bearing in mind the lower values which are worked to, it was seen that the tensile strength of thick plates would surely drop below 48,000 lb. per sq. in., but that the lowest carbons in the thinner plates would probably not run the tensile strength below 48,000 lb. Therefore, in order to permit designers of welded tanks when plates $\frac{3}{4}$ in. or under in thickness are used, to have the benefit of this figure, the tensile strengths have been specified at 48,000 lb. for plates $\frac{3}{4}$ in. or under and 45,000 lb. for plates over $\frac{3}{4}$ in. in thickness.

Requirements for elongation, including modifications for thick and thin plates, are substantially the same as for structural steel for cars. Bend test requirements, however, are somewhat more severe, the bend specimen being required to bend flat on itself through 180 deg. irrespective of the thickness of the plate.

It is believed that the specifications will meet with general approval. Two of the leading consumers of this material, who are manufacturers of tanks for cars by the forge-welding process, are members of the sub-committee and voted favorably. Two manufacturers who are not members of the Society were consulted and expressed themselves as favorable to the proposed specifications.

Respectfully submitted on behalf of the sub-committee,

F. E. ABBOTT,
Chairman.

APPENDIX II.

REPORT OF SUB-COMMITTEE XII
ON
LADLE TEST INGOT INVESTIGATION.

Sub-Committee XII presents as its report to Committee A-1 the following report submitted to it by Mr. J. R. Cain, Chemist, and Mr. H. S. Rawdon, Associate Physicist, of the Bureau of Standards, under whose direction the investigation of ladle test steel ingots is being conducted. This report describes the work which has been done since the presentation of the last report[1] of the sub-committee on this subject, and embodies conclusions of the investigators.

REPORT BY J. R. CAIN AND H. S. RAWDON.

In the last report of Sub-Committee XII on this subject, the following program for further work was suggested:

1. Extension of the metallographic study to several planes through the ingot, with provision, if possible, for a closer estimation of sulfur and carbon differences metallographically.
2. Pouring of selected ingot types at one time and place from two grades of steel—a low-carbon type (grade No. 1) and a medium-carbon type (grade No. 3), each type having compositions and metallurgical treatments designed to give (*a*) "rising" steel (not completely freed from gases) and (*b*) "quiet" steel, such as would give sound ingots; the ingots poured as in (*a*) to be given aluminum treatment to make them sound Examination of these ingots in a manner similar to the present investigation.
3. Following completion of this part of the investigation, a similar study to be made of selected ingot types

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVI, Part I, p. 129 (1916).

poured in molds having the same mass, in such way as to secure uniform chilling effect.

4. Finally, studying the question of relation of test ingot analyses to composition of rolled products.

The present report covers the following work: The metallographic examination of medial and transverse and the chemical examination of medial sections of four sets of ladle test ingots poured in five typical shapes of molds selected from among those investigated in the previous report as representing present practice. Two sets of ingots from two different heats of low-carbon steels (about 0.2 per cent carbon)—Series B— were made by the Carnegie Steel Co., and two sets from two different heats of medium-carbon steel (about 0.6 per cent carbon)—Series A— were made by the Cambria Steel Co. One heat each of the low-carbon and the medium-carbon steel was a "rising" steel and received aluminum treatment in the mold. The other heats were poured into the molds without aluminum addition. The purpose of this work was (*a*) to compare the five ingot types, and (*b*) to demonstrate whether or not aluminum treatment in the mold removed any defects found in the corresponding ingots of the companion heat and particularly whether aluminum treatment would give sound ingots with "rising" steel, these being difficult to secure in such steel without its use.

The works' analyses of the heats are as follows:

TYPE OF STEEL		CARBON, PER CENT.	MANGANESE, PER CENT.	PHOSPHORUS, PER CENT.	SULFUR, PER CENT.
Low-Carbon (Series B)	Aluminum treated	0.19	0.45	0.010	0.031
	No aluminum	0.20	0.46	0.014	0.034
Medium-Carbon (Series A)	Aluminum treated	0.58	0.51	0.033	0.032
	No aluminum	0.56	0.99	0.016	0.033

The ingot molds for this work were assembled on the platform in front of the open-hearth furnace and filled while the workmen were filling the large molds from the ladle. Some of the molds were provided with long steel rods serving as handles and were filled by holding them under the stream of metal flowing out from the ladle; to facilitate this the opening in the ladle was partially closed. Molds not provided with a handle were filled from an iron spoon in which a sufficient amount of metal was caught by holding the spoon underneath the ladle opening.

By pouring all the test ingots at one time it was easy to see the comparative advantages or disadvantages of types from the standpoint of ease and certainty of manipulation. In this connection it is necessary that the shape and type of mold be considered together with the question of ingot type. Molds of Types 1 and 2 (see Table I) as constructed showed marked inferiority in these regards because: (1) they were not provided with handles, but had to be filled from a spoon, which resulted in the metal in the spoon becoming chilled before it reached the mold; in a few cases ingots of these types could not be poured in the first trials; (2) the mold for Type 1 is in two pieces and had to be assembled by clamps, which is time-consuming and awkward; (3) both molds have very small openings, and are therefore hard to fill; (4) it was found to be difficult in some cases to remove the ingots from both types of mold after the metal had solidified, especially with molds of Type 1; (5) the mold for Type 1 is not symmetrical, consequently the cooling takes place unsymmetrically. Type 1 gave very defective ingots, which might possibly be accounted for by the unequal rate of cooling on the two sides. The practical disadvantages of these two types were so marked as compared with the other types of molds that they would in themselves seem sufficient grounds for recommending discontinuance of Types 1 and 2, unless some change were made in the design of the molds. The mold for Type 1 would be difficult to modify, because it is a split mold. In addition to the disadvantages just detailed, so far as shown by this work and the work previously reported by the sub-committee, the ingots obtained from molds of Types 1 and 2 were the worst of the series in respect to soundness and freedom from segregation.

Some variations in the use of aluminum, made necessary by circumstances, were adopted. The aluminum additions in the low-carbon steels were in the form of wire; in the medium-carbon steels aluminum shot were used. The rate of addition in each case was 2 grams of aluminum per 5 lb. of steel. In the case of low-carbon steels the aluminum was placed in the bottom of the mold just prior to pouring, except in molds of Types 1 and 2. In these molds rapid chilling action was anticipated, and since the metal reached the molds at a low temperature (due to spoons being used for filling, as stated above), the aluminum wire was placed in the bottom of the spoon instead of in the mold. Thus in all cases the molten steel flowed on to the aluminum and conditions were favorable for the rapid diffusion of the latter before any oxidation of the aluminum by air could take place. In the case of the medium-carbon steels the practice was the same, except that in pouring Type 2 the shot were thrown into the stream of metal flowing into the mold. In spite of these precautions to promote rapid intermingling of the two metals, it was found in some of the ingots that the imprint of the aluminum wire originally in the bottom of the mold could be observed. However, that the aluminum performed its function of imparting soundness to the metal, is shown by the comparison of the photographs of the split ingots made with and without aluminum.

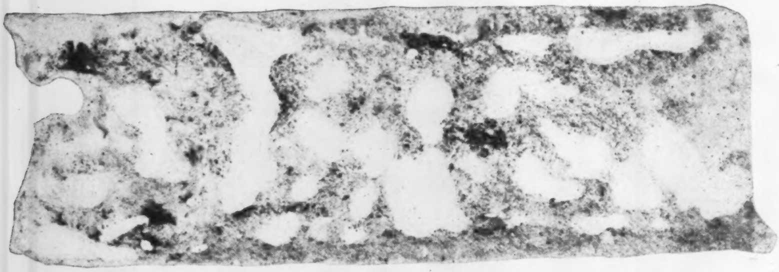
TABLE I.—ANALYSES OF THE MEDIALLY SPLIT INGOTS THAT WERE METALLOGRAPHICALLY EXAMINED.

ALL VALUES ARE PER CENT.

Type of Ingot.	Position of Drill Hole.	Low-Carbon (Series B).						Medium-Carbon (Series A).					
		No Aluminum.			Aluminum Treatment.			No Aluminum.			Aluminum Treatment.		
		C	P	S	C	P	S	C	P	S	C	P	S
No. 1—Rectangular Prism.	Top	0.26	0.013	.....	0.20	0.010	0.032	0.58	0.017	0.027	0.60	0.033	0.030
	Middle	0.24	0.017	0.037	0.21	0.010	0.034	0.57	.....	0.024	0.59	0.032	0.038
	Bottom	0.24	0.013	0.032	0.20	0.008	0.032	0.54	.....	0.028	0.60	0.033	0.038
No. 2—Wedge	Top	0.22	0.013	.....	....	.....	.....	0.50	.....	.....	0.59	.....	.....
	Middle	0.20	0.013	.....	....	.....	.....	0.59	0.017	0.024	0.60	0.036	.....
	Bottom	0.20	0.013	.....	....	.....	.....	0.46	0.016	0.030	0.58	0.033	0.333
No. 3—Hemisphere.	Top	0.25	0.014	0.024	0.22	0.009	0.030	0.58	0.015	0.027	0.54	0.034	0.033
	Middle	0.24	0.014	0.034	0.18	0.013	.....	0.53	0.015	0.032	0.56	0.034	0.032
	Bottom	0.28	0.013	0.027	0.22	0.009	0.038	0.51	0.017	0.027	0.56	0.030	0.032
No. 4—Truncated Pyramid.	Top	0.23	0.013	0.027	0.21	0.010	0.033	0.48	0.015	0.031	0.59	0.035	.....
	Middle	0.26	0.014	0.035	0.22	0.010	0.033	0.59	.....	.....	0.56	0.031	0.030
	Bottom	0.24	0.013	0.027	0.22	0.010	0.034	0.44	0.016	0.031	0.58	0.033	0.032
No. 5—Truncated Cone.	Top	0.20	0.011	.....	0.20	0.009	0.034	0.60	0.014	0.031	0.58	0.033	0.031
	Middle	0.22	.....	.....	0.21	0.011	.....	0.48	0.015	0.032	0.60	0.034	0.032
	Bottom	0.24	0.022	.....	0.21	0.008	0.034	0.58	0.016	0.032	0.60	0.033	0.032

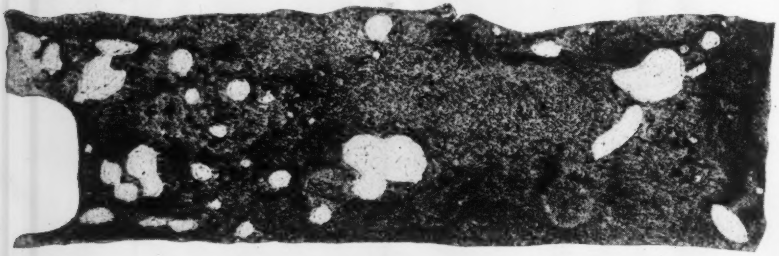
In order to expedite the work and in view of the congested

Top.



Top.

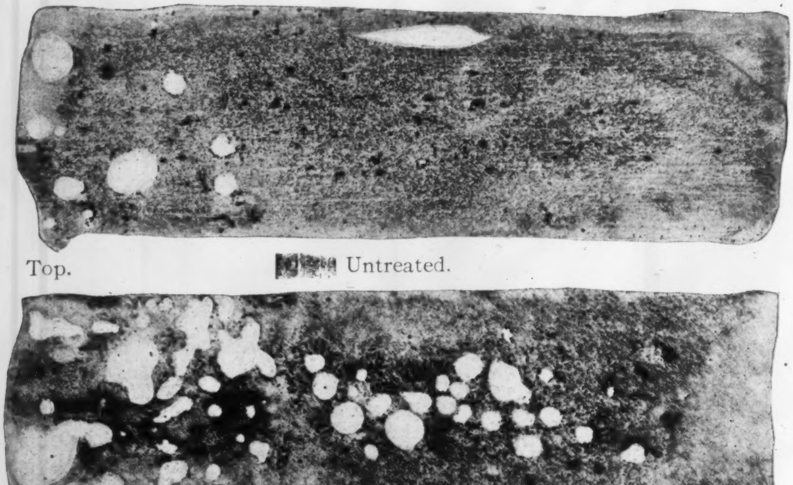
Untreated.



Treated.

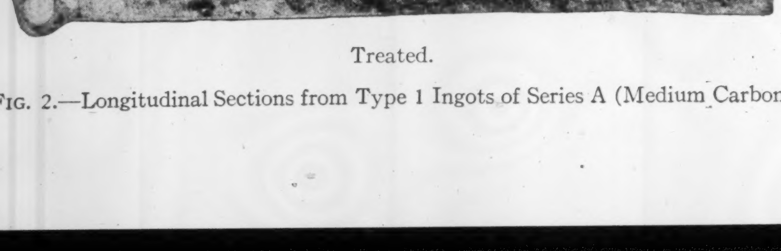
FIG. 1.—Longitudinal Sections from Type 1 Ingots of Series B (Low-Carbon).

Top.



Top.

Untreated.



Treated.

FIG. 2.—Longitudinal Sections from Type 1 Ingots of Series A (Medium Carbon).

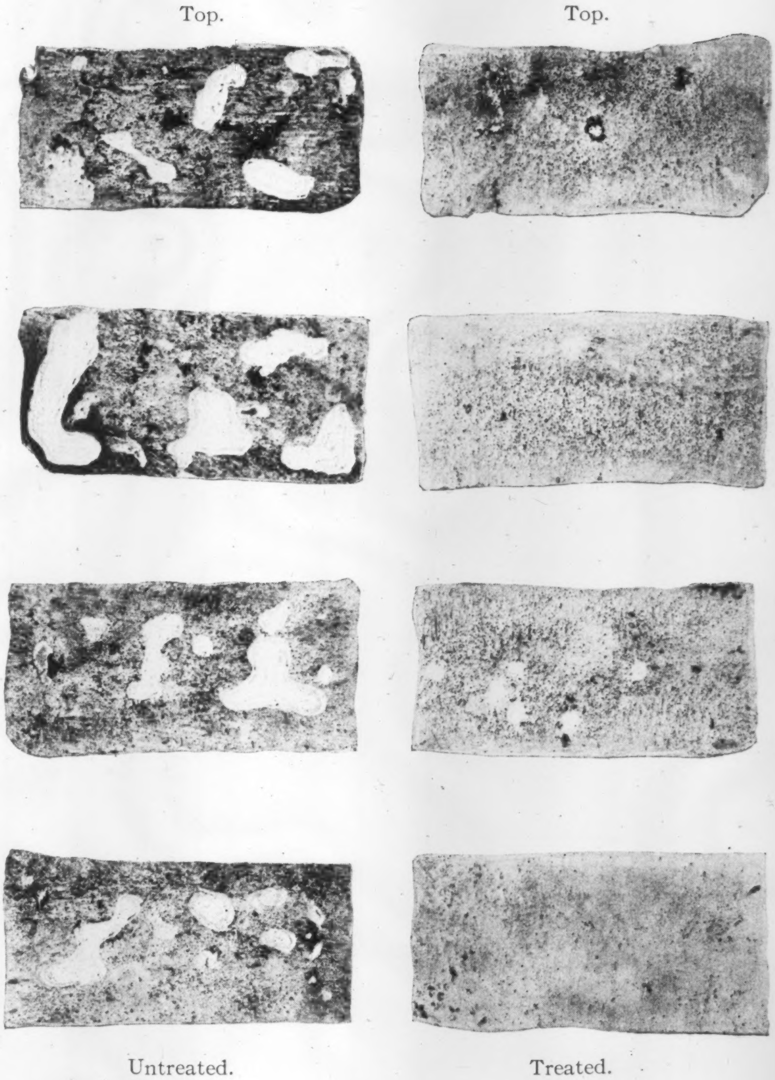

Top.
Top.
Untreated.
Treated.

FIG. 3.—Transverse Sections from Type 1 Ingots of Series B (Low Carbon).

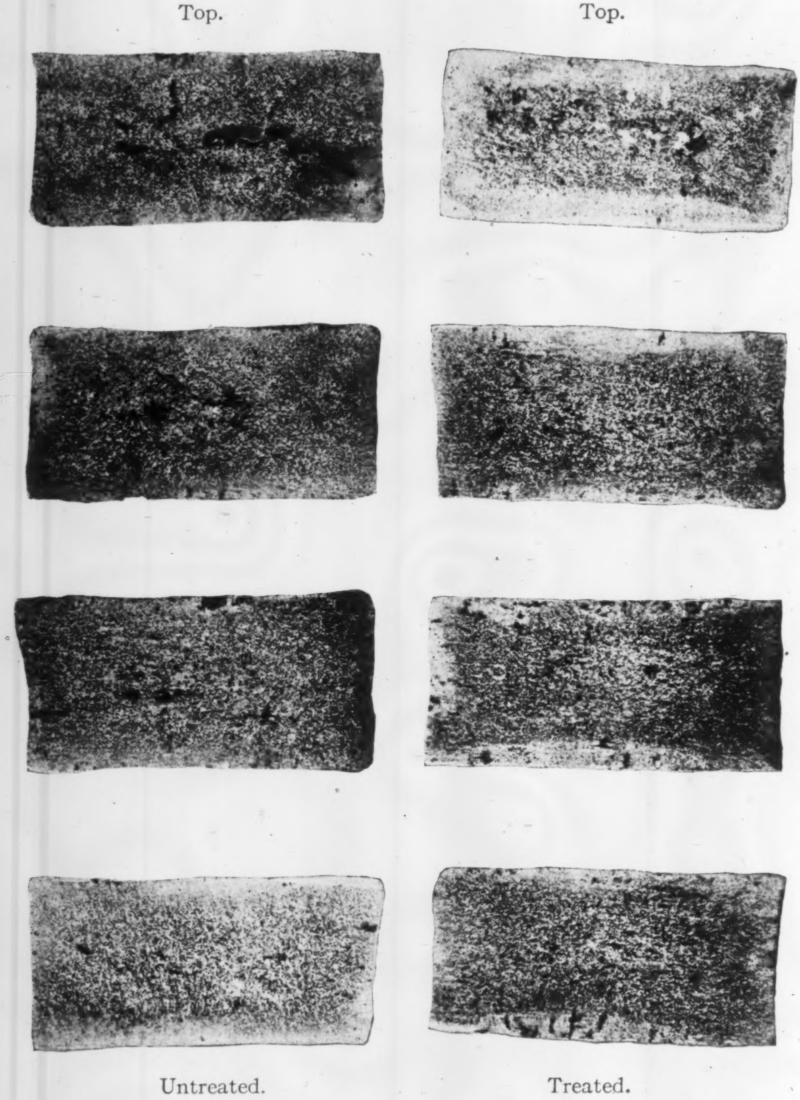
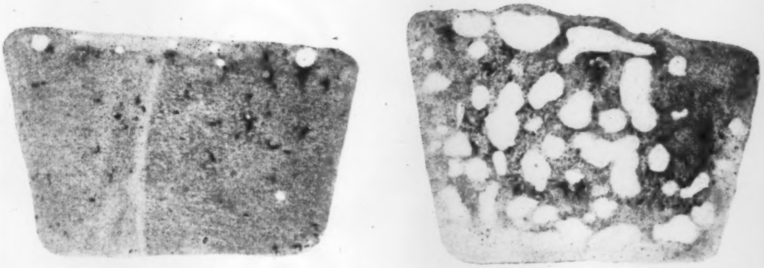
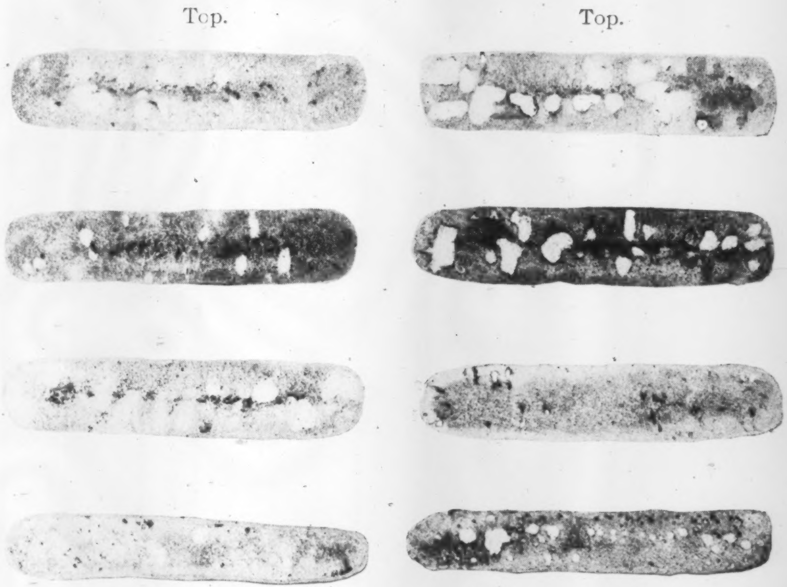

Top.
Top.
Untreated.
Treated.

FIG. 4.—Transverse Sections from Type 1 Ingots of Series A (Medium Carbon).



Untreated. Treated.

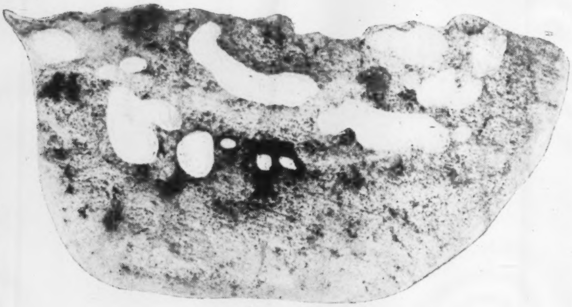
Longitudinal Sections.



Untreated. Treated.

Transverse Sections.

FIG. 5.—Sections from Type 2 Ingots of Series A (Medium Carbon).



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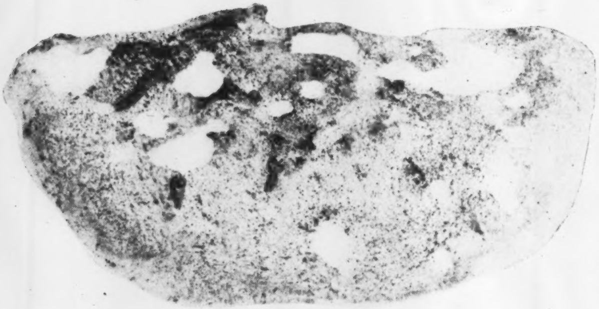
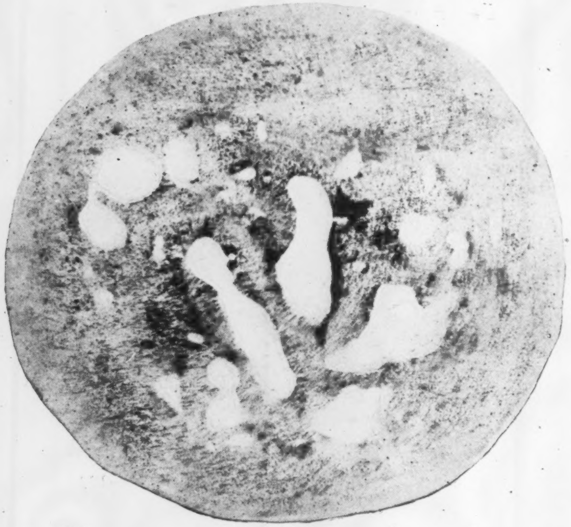


Treated.

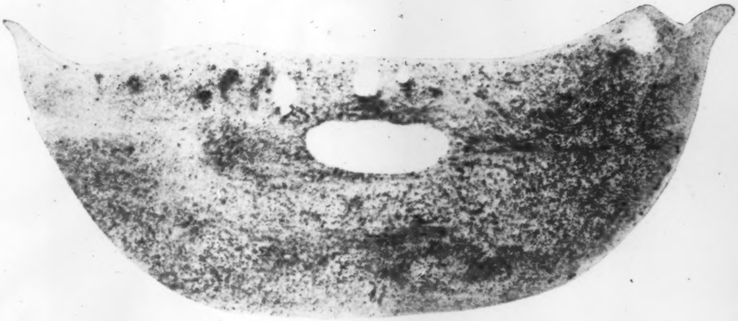
Longitudinal Sections.



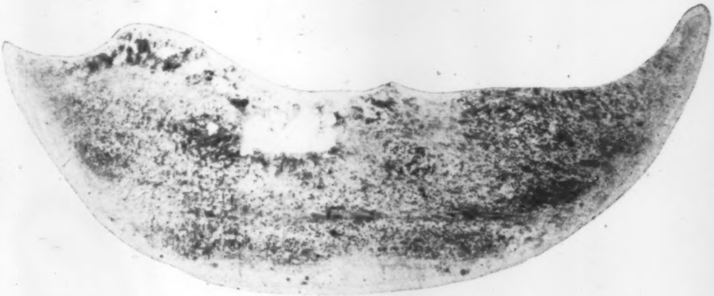
Untreated.

Transverse Section.

FIG. 6.—Sections from Type 3 Ingots of Series B (Low Carbon).

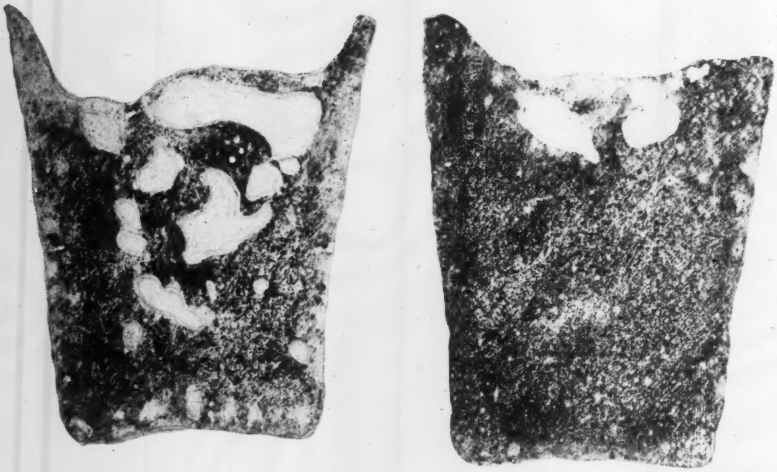


Untreated.



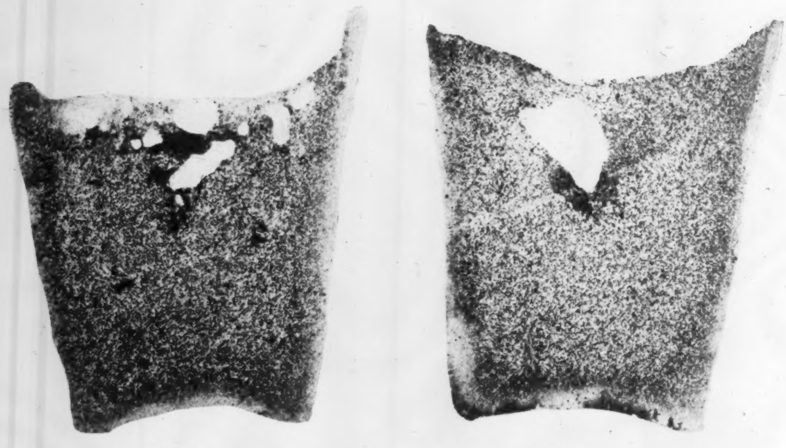
Treated.

FIG. 7.—Longitudinal Sections from Type 3 Ingots of Series A (Medium Carbon).



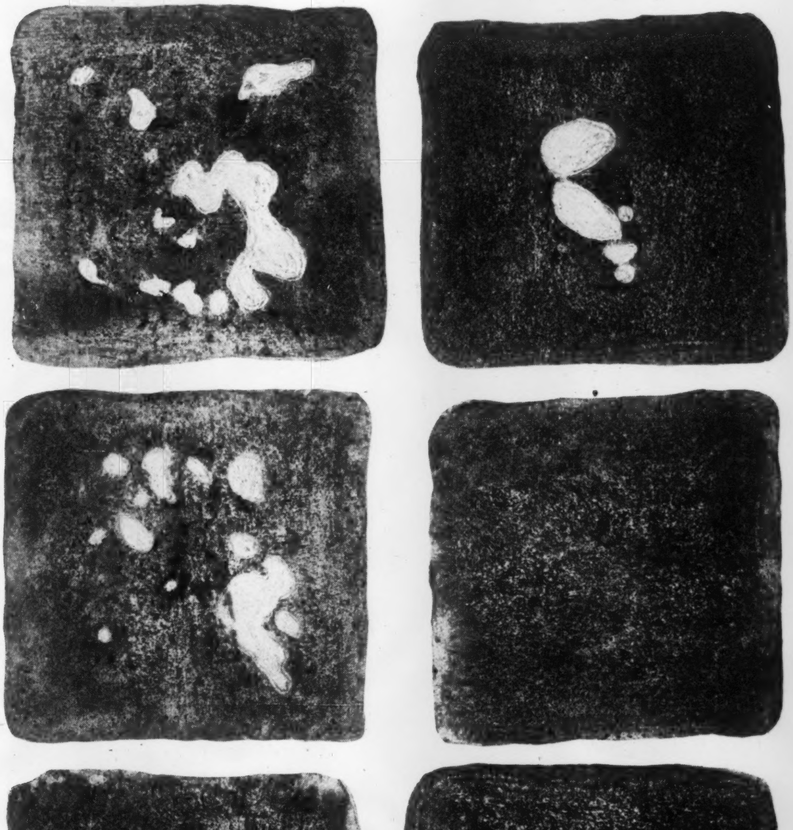
Untreated. Treated.

FIG. 8.—Longitudinal Sections from Type 4 Ingots of Series B (Low Carbon).



Untreated. Treated.

FIG. 9.—Longitudinal Sections from Type 4 Ingots of Series A (Medium Carbon).



Top. Top.

Untreated. Treated.

FIG. 10.—Transverse Sections from Type 4 Ingots of Series B (Low Carbon).

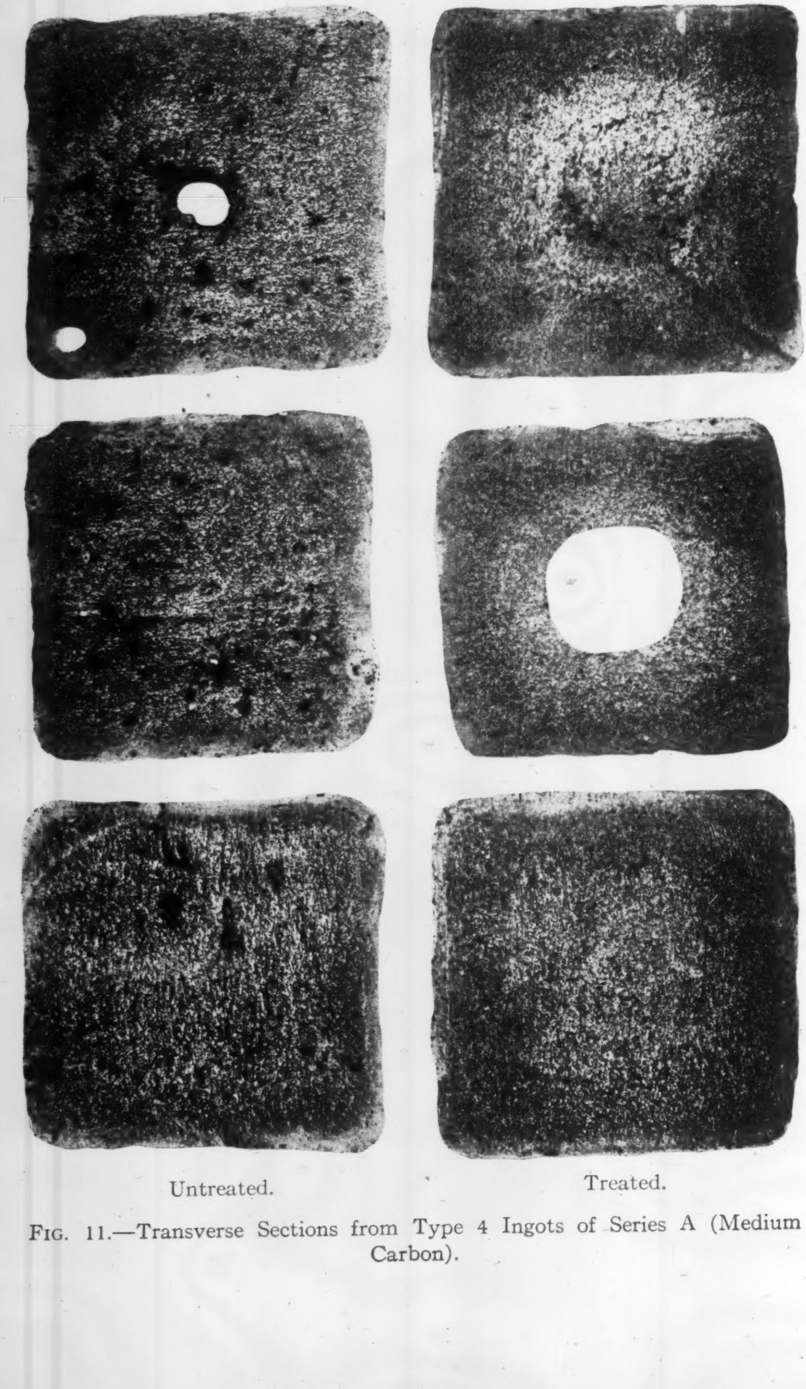
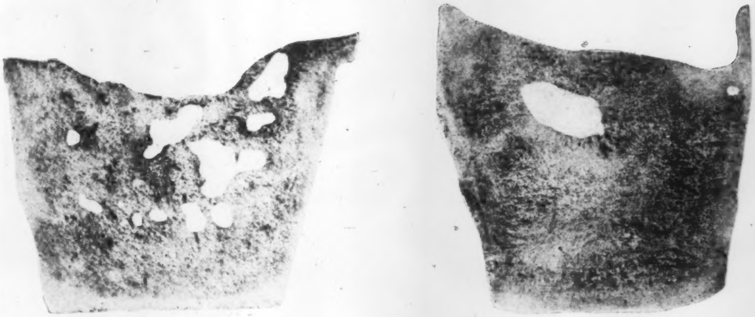
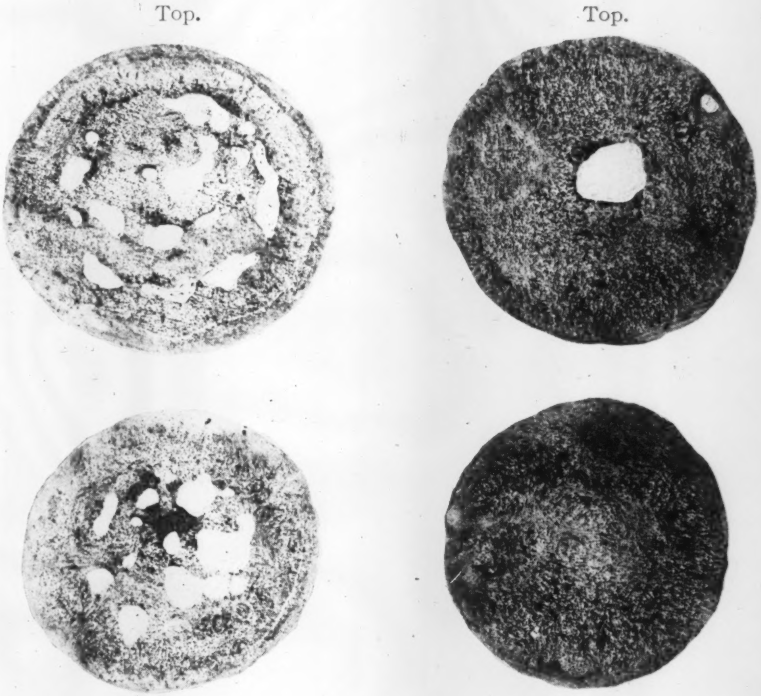

Top.
Top.
Untreated.
Treated.

FIG. 11.—Transverse Sections from Type 4 Ingots of Series A (Medium Carbon).



Untreated. Treated.

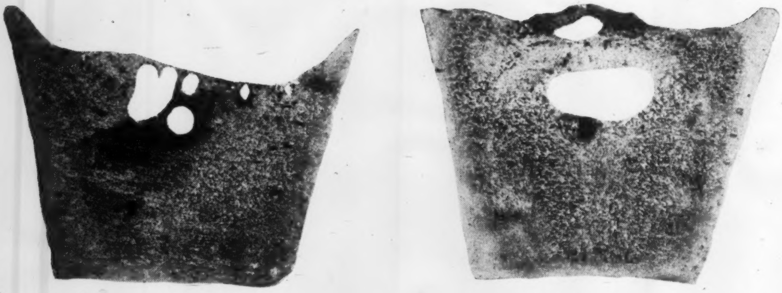
Longitudinal Sections.



Untreated. Treated.

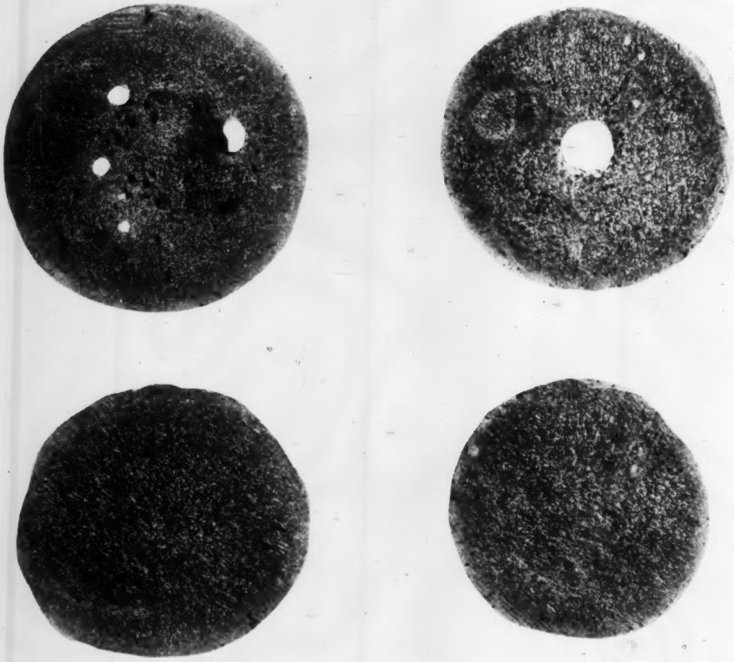
Transverse Sections.

FIG. 12.—Sections from Type 5 Ingots of Series B (Low Carbon).



Untreated. Treated.

Longitudinal Sections.



Untreated. Treated.

Transverse Sections.

FIG. 13.—Sections from Type 5 Ingots of Series A (Medium Carbon).

conditions in the laboratories concerned, the chemical determinations were distributed among Messrs. Cain, Gibboney and Hopkins. In general, carbon determinations were made by Mr. Cain, phosphorus determinations by Mr. Gibboney and sulfur determinations by Mr. Hopkins. Some difficulties were experienced in a few cases in obtaining sufficient drillings for all the analyses. The drill holes were located in the top, middle and bottom of the ingots. The A. S. T. M. gravimetric method for sulfur (2.5-gram samples) and the alkalimetric method for phosphorus (1-gram samples) were used respectively for these elements; most of the carbon determinations were made by Mr. Cain, using a new, rapid electrolytic method soon to be described. The results of the chemical survey are shown in Table I.

From an inspection of these results it is seen that so far as the low-carbon grade of steel is concerned the aluminum treatment has had no particular value. However, the medium-carbon grade shows a considerable superiority for the aluminum-treated ingots. Thus, comparing the carbon differences throughout the medium-carbon ingots, the following results are found:

SERIES A.

	UNTREATED INGOTS.	ALUMINUM-TREATED INGOTS.
No. 1	0.04	0.01
No. 2	0.13	0.02
No. 3	0.07	0.02
No. 4	0.15	0.03
No. 5	0.12	0.02

The comparisons for phosphorus and sulfur cannot be made throughout for these elements, because some determinations are lacking for want of sufficient drillings. As far as such comparison can be made, however, it cannot be said from this series of results that the aluminum treatment has affected these elements one way or the other, since the untreated ingots themselves show no marked segregation in sulfur and phosphorus (except Type 2 for sulfur).

The metallographic work consisted in making photographs and sulfur prints of the medially and transversely cut sections of the ingots. These prints showed some superiority for the aluminum-treated ingots, as can be seen by inspection. At this time, however, no metallographic conclusions affecting selection of ingot types seem warranted.

As a result of the work detailed in this report the following conclusions have been reached:

1. The ingot molds with large openings and provided with handles were found easiest to fill.

2. The effect on chemical homogeneity of aluminum additions to the low-carbon steels is slight, but there is marked improvement in soundness.

3. The effect of aluminum additions to the medium-carbon steels was to materially eliminate carbon segregation in all types, as well as to produce physical soundness.

4. Drill holes in aluminum-treated ingots may be located in the most convenient place.

It is the feeling of the sub-committee that, because of its importance, this uncompleted investigation should be resumed at the earliest practicable date, but that it is inadvisable to continue the work during the war.

This report has been submitted to letter ballot of the sub-committee, which consists of 11 members, all of whom have voted affirmatively.

Respectfully submitted on behalf of the sub-committee,

J. H. GIBBONEY,
Chairman.

ADDENDUM

TO

REPORT OF COMMITTEE A-1.

At a meeting of Committee A-1 held Monday evening, June 23, 1919, prior to the presentation of its annual report to the Society, the following matters were considered for submission to the Society in connection with the printed report of the committee:

Proposed Revision in Tentative Specifications for Low-Carbon Steel Track Bolts (A 76 – 18 T).[1]

Sub-Committee I on Steel Rails and Accessories recommended that Section 10 of the Tentative Specifications for Low-Carbon Steel Track Bolts (A 76–18 T) be revised to read as follows:

> The bolts and nuts shall conform to the dimensions specified by the purchaser. They shall be neatly formed and free from fins or nicking. The head of the bolt shall be concentric with, and firmly joined to, the shank with the underside at right angles to the axis of the bolt. The threads shall be sharp and true to gage and of the design specified by the purchaser. The nuts shall have a hand free fit on the bolt from two to six turns, and wrench tight the balance of the screw length without distorting the threads or twisting the shank. They shall be screwed on the bolts before packing, a sufficient number of turns to hold them in place until used. A variation of $\frac{1}{32}$ in. under and $\frac{1}{64}$ in. over the specified diameter of the shank of the bolt will be permitted. The diameter of rolled thread shall not exceed the diameter of the shank more than $\frac{1}{16}$ in. for bolts $\frac{7}{8}$ in. in diameter and under, nor more than $\frac{3}{32}$ in. for bolts 1 in. in diameter and over. The outside diameter of the finished rolled thread shall not exceed the diameter of the shank of a cut thread bolt of corresponding size. The

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[1] See pp. 440–443.—Ed.

length of the bolt under the head shall not vary more than $\frac{1}{8}$ in. from that specified. A variation in the dimensions of the elliptical shoulders under the head of $\frac{1}{32}$ in. and a taper of the shoulder of $\frac{1}{32}$ in. will be permitted.

Inasmuch as this proposed revision had been received too late to be referred to letter ballot vote of the committee, the chairman was directed to recommend to the Society that it be included simply as a part of the report of the committee.

PROPOSED REVISION IN SPECIFICATIONS FOR AUTOMOBILE CARBON AND ALLOY STEELS (A 29 – 18)[1].

Sub-Committee X on Automobile Steels proposed a revision of Table IV on Automobile Chromium Steels of the Standard Specifications for Automobile Carbon and Alloy Steels (A 29–18), as follows:

(*a*) Change the permissible range in chromium in the first three classes in the table from 0.65–0.85 to 0.60–0.90 per cent, leaving the desired chromium 0.75 per cent as before.

(*b*) Omit the fourth, fifth and seventh classes in the table and substitute therefor the following fully representative type of oil-quenching chromium steel:

	DESIRED.	PERMISSIBLE RANGE.
Carbon, per cent	1.00	0.95 – 1.10
Manganese, "	0.35	0.20 – 0.50
Phosphorus, "		Not over 0.03
Sulfur, "		Not over 0.03
Chromium, "	1.35	1.20 – 1.50

Inasmuch as this proposed revision had been received too late to be referred to letter ballot vote of the committee, the chairman was directed to recommend to the Society that it be included simply as a part of the report of the committee.

RECOMMENDATIONS WITH RESPECT TO THE PHOSPHORUS AND SULFUR NOTE

As a result of the consideration of the nature of its recommendation to the Society concerning the note providing for increased phosphorus and sulfur limits during the war emergency (see report of the committee, pages 139–141), the committee recommends to the Society that the 43 specifications to which this note has applied be divided into two classes: (1) Those specifications from which the note is to be removed at the present annual meeting, as of July 1, 1919; (2) Those specifications from which the note is not to be removed at this time, and consideration of its removal deferred until the annual meeting in 1920.[1]

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[1] 1918 Book of A.S.T.M. Standards.

Respectfully submitted on behalf of the committee,

J. A. CAPP,
Chairman.

C. L. WARWICK,
Secretary.

EDITORIAL NOTE.

The proposed revisions in the Standard Specifications for Open-hearth Steel Girder and High Tee Rails (A 2–12) referred to in this report were accepted for publication as tentative and appear on page 777.

The proposed Tentative Specifications for Steel Plates for Forge Welding were accepted for publication as tentative and appear on pages 448–453.

The recommendations contained in the Addendum to the Report of the Committee were approved. For detailed information concerning the action of the Society on the Phosphorus and Sulfur Note, see Summary of the Proceedings, pages 16–19.

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[1] For complete list of the specifications in these two classes proposed by the committee, and the action taken upon the recommendation of the committee, see Summary of the Proceedings, pp. 17–19.—ED.

REPORT OF COMMITTEE A-2

ON

WROUGHT IRON.

During the year the committee has held one meeting. A number of general subjects have been considered, and are reported upon briefly, as follows:

At the request of the National Bar Iron Association, an investigation of Bushelled Steel has been instituted with the idea of ascertaining the advisability of writing specifications for this product.

The committee has continued the study of the vibratory test. The Bureau of Standards has devised an improved machine which, it is hoped, may be adapted to the testing of staybolt iron.

Specifications for hollow staybolt iron have been considered, but it is found to be inadvisable to write specifications at this time as the manufacture of this kind of iron has not been fully developed.

A revision in the requirements for dimensions, proof loads and weights for Class B chain in the Standard Specifications for Iron and Steel Chain (A 56–18) is under consideration.

The committee also has under consideration, in cooperation with Committee A-1 on Steel, the extension of the Standard Specifications for Welded Wrought-Iron Pipe (A 72–18) to include pipe up to 12 in. in diameter for both Standard and Extra Strong Pipe.

The committee reports progress on the preparation of definitions of terms applied to the various grades of wrought iron.

PROPOSED REVISIONS OF STANDARDS.

1. *Specifications for Engine-Bolt Iron* (*A 40–18*).—It is recommended that Section 1 of these specifications be amended when the Book of Standards is next published by inserting the

words "all pig" before the word "puddled," making the section read as follows:

> "The iron shall be made from all pig puddled iron and shall be free from any admixture of iron scrap or steel."

The letter ballot vote of the committee on this recommendation is as follows: Affirmative, 29; negative, 0; not voting, 11.

2. The committee has had under consideration, in conjunction with Committee A-1, a letter from one of the members of the Society, Mr. H. J. Skelton of London, regarding the use of the Birmingham Wire Gage in this country, and recommending the adoption instead of the Birmingham Gage and the Standard Wire Gage adopted in England in 1914. It has been decided by the two committees to retain the Birmingham Wire Gage, but to recommend that when the Book of Standards is next published the heading in the Tables of Standard Weights in the various specifications for Tubes be changed from the present form

Thickness.	
Inches.	B.w.g.

to read as follows:

Thickness. Birmingham Wire Gage.	
No.	Inches.

This recommendation affects only one specification for which this committee is responsible, namely Standard Specifications for Lap-Welded Iron Boiler Tubes (A 38-18). The revision, moreover, is one of form as distinguished from substance.

PROPOSED NEW STANDARDS.

Proposed Tentative Specifications for Extra-Refined Wrought-Iron Bars.—These specifications have been prepared to cover large rectangular bars used in the construction of locomotives and for similar purposes. The iron described by the present

Specifications for Refined Wrought-Iron Bars (A 41–18) is not of the quality desired, especially with reference to the raw material, while the requirements of the present Specifications for Engine Bolt Iron (A 40–18) are too severe for large rectangular bars. The specifications are appended to this report,[1] and the committee recommends that they be published as tentative. The letter ballot vote of the committee on this recommendation is as follows: Affirmative, 26; negative, 4; not voting, 10.

This report has been referred to letter ballot of the committee, which consists of 40 members, of whom 33 have voted affirmatively, 0 negatively, and 7 have refrained from voting.

Respectfully submitted on behalf of the committee,

H. E. SMITH,
Chairman.

J. B. YOUNG,
Secretary.

EDITORIAL NOTE.

The proposed revision in the Standard Specifications for Engine-Bolt Iron (A 40–18) referred to in this report was accepted for publication as tentative and appears on page 778.

The proposed Tentative Specifications for Extra-Refined Wrought-Iron Bars were accepted for publication as tentative and appear on pages 454–457.

For the recommendation of Committee A-2 with respect to the Phosphorus and Sulfur Note appearing on the Standard Specifications for Iron and Steel Chain (A 56–18), see Summary of the Proceedings, page 20.

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[1] See pp. 454–457.—ED.

REPORT OF COMMITTEE A-5

ON

CORROSION OF IRON AND STEEL.

The report of Committee A-5 consists of the reports of Sub-Committee II on Preservative Metallic Coatings for Metals, and Sub-Committee III on Inspection of Fort Sheridan, Pittsburgh and Annapolis Tests.

Sub-Committee II presents a brief statement regarding its work for the past year. The work of the sub-committee was interrupted more by the war than that of the Sub-Committee on Inspection which had its program clearly defined and in progress.

The report of Sub-Committee III gives the result of the continued inspection of the sheets of bare metal exposed at Fort Sheridan, Ill., Pittsburgh, Pa., and Annapolis, Md. The statement made in last year's report that certain results are being obtained becomes more evident as the tests progress.

Five groups of low-copper sheet metals, three from Series A and two from Series B, have been eliminated from the test at Pittsburgh, as failed.

The conditions of the sheets with photographs and tables showing the results of the inspection and certain generalizations are given in detail in the report of the sub-committee.

This exposure test covers only bare metal sheets exposed to atmospheric corrosion, and it may or may not be justifiable to apply the result of these tests to coated metal exposed to other conditions of service. It is expected that further tests will establish these points.

In an appendix to the report there will be found the results of re-analyses of copper in a number of the sheets in the present corrosion tests. The percentages there reported are to replace those in the tables previously reported in the 1916 and 1918 Proceedings.[1]

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[1] Vol. XVI, Part I, pp. 155–170 (1916); Vol XVIII, Part I, pp. 160–179 (1918).

This report has been submitted to letter ballot of the committee, which consists of 44 members, of whom 29 have voted affirmatively, none negatively, and 15 have refrained from voting.

Respectfully submitted on behalf of the committee,

S. S. VOORHEES,
Chairman.

EDITORIAL NOTE.

For Discussion of this report see page 241.

REPORT OF SUB-COMMITTEE II ON PRESERVATIVE METALLIC COATINGS.

One of the problems which fall within the scope of this sub-committee is the investigation of different methods for the testing of metallic coatings. During the past year the work of the sub-committee has comprised a study of a proposed new method for zinc coatings, which was brought to the attention of the sub-committee. The method was proposed as one which might well replace the Preece Test, of which Committee A-5 has expressed its disapproval,[1] and which might also be used in a quantitative way to show rather accurately the weight of the coating in the thin spots.

Essentially, the test consists of immersion of the specimen in dilute sulfuric acid to which an oxidizer has been added to retard polarization due to hydrogen evolved. The time required for the appearance of the bare base metal should be a measure of the thickness of the zinc coating on such areas. The Bureau of Standards was asked to study the test in detail and to systematize the method of procedure, after which it was proposed to carry out a series of cooperative tests similar to those conducted by the sub-committee on the common methods for testing zinc coatings now in commercial use.[2] Considerable work was done by the Bureau of Standards under the direction of Mr. A. N. Finn in the endeavor to perfect the method so that it might be recommended by the sub-committee for testing. In general the conclusion reached was negative.

The procedure of the test is briefly as follows: A 20-per-cent solution (by weight) of sulfuric acid is used, to each liter of which 250 g. of sodium bichromate are added. The specimen is immersed and the solution, which is kept at a temperature of 25° C., is agitated continuously by means of a mechanical stirrer. The zinc changes color gradually to a dark green as it is attacked by the acid, and the abrupt change to the light silvery color of the iron, when the latter is exposed, forms a very definite "end-point" of the reaction.

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[1] *Proceedings*, Am. Soc. Test Mats., Vol. XI, p. 100 (1911).

[2] *Ibid.*, Vol. XVII, Part I, p. 144 (1917).

The rate at which pure zinc is dissolved by this solution was determined and also the retarding influence of the zinc sulfate resulting from the reaction as the acid is neutralized. The retardation of the rate of solution is very pronounced, as is indicated in Fig. 1, and may amount to as much as 28 per cent.

Although the method of locating thin spots is more accurate than either the Preece test or the basic-lead-acetate method, the difficulties of proper application for quantitative estimation of the thickness of coatings are such that it does not seem advisable to recommend it for commercial practice.

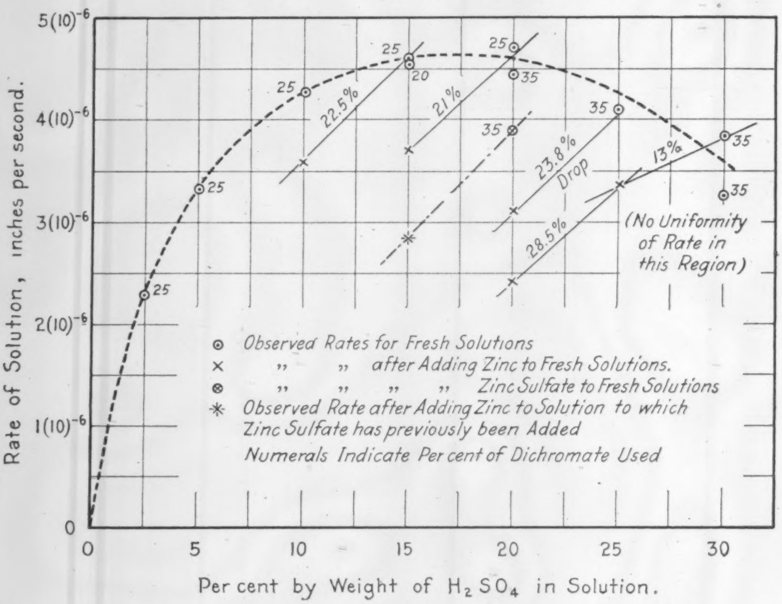

FIG. 1.—Observed Rates of Solution for Cast Zinc in Mixtures of Sulfuric Acid and Sodium Bichromate in Water.

The sub-committee was agreed that the preliminary work by the Bureau of Standards was sufficient to show the merits and the disadvantages of this proposed test and that a further series of cooperative tests by the sub-committee was unnecessary and undesirable.

Sub-Committee II will welcome any suggestions from members of the Society as to other proposed methods of testing and will endeavor to determine the value of such methods.

REPORT OF SUB-COMMITTEE III ON INSPECTION OF THE FORT SHERIDAN, PITTSBURGH AND ANNAPOLIS TESTS.

Sub-Committee III on Inspection has held three meetings during the past year.

First Meeting.—The first meeting was held in Pittsburgh, Pa., on October 7, 1918, with Messrs. Aupperle, Buck, Cooper, Fleming, McDonnell, Smith, Wheaton, Gibboney, and Finn, representing Voorhees (*ex-officio*) present, the representative of the Bureau of Steam Engineering of the U. S. Navy Department being absent.

On account of the comparatively slow rates of corrosion for the test sheets exposed at Fort Sheridan and Annapolis, it was unanimously agreed that for the present the full purpose of inspections could be obtained by annual visits to these locations, but to retain the semi-annual inspection interval for the Pittsburgh sheets.

The Pittsburgh sheets were inspected on October 7, 1918, followed by inspection of the Annapolis sheets on October 8, 1918. Members filing data sheets for these inspections are as follows:

Pittsburgh.—Messrs. Aupperle, Buck, Cooper, Fleming, McDonnell, Smith, Wheaton and Gibboney.

Annapolis.—Messrs. Aupperle, Buck, Cooper, McAdam, McDonnell, Smith, Wheaton and Gibboney.

The results of these inspections are shown in composite form as Tables I and II, Plates I and II.

Photographic records of all failed sheets, and a few representative sheets or groups of sheets showing progressive information at the Pittsburgh test, were made on October 7, 1918, representing an exposure period of 22 months.

Figs. 1 and 2 represent the condition of sheets A 31 and 32, 33 and 34 (No. 22 Gage Bessemer Steel, Series A), showing progressive corrosion at the lower ends of sheets. These sheets were reported in the April, 1918, inspection as having failed. Fig. 3 represents the condition of Sheets A 35 to 47, inclusive, grouped to show general condition of failure. All of these sheets, excepting No. 39, were reported in the April, 1918, inspection as having failed due to holes or ragged edges, or both conditions. Sheet A 39 has now failed.

Fig. 4 represents the conditions of Sheet B 37 (No. 22 Gage Open-hearth Steel, Series A), having failed due to hole in lower end of the sheet.

Figs. 5 and 6 represent the condition of Sheets D 30 and 36 and 38 (No. 22 Gage Low-Copper Pure Iron, Series A), failed due to holes in lower ends of sheets.

Figs. 7 and 8 represent the condition of Sheets E 32 and E 36 (No. 22 Gage Puddled Iron, Series A), failed due to holes in lower ends of sheets.

Figs. 9 and 10 represent the condition of Sheets O 25 to 28 inclusive, and O 29 to 36 inclusive (No. 22 Gage Low-Copper Open-hearth Steel, Series A), grouped as appearing on test rack, these sheets having been reported in April, 1918, as failed. Attention is directed to the fact that the composition of these sheets shows abnormally high silicon content for commercial open-hearth sheet steel.

Figs. 11 to 16 inclusive represent the condition of Sheets S 29 to 42 inclusive (No. 22 Gage Low-Copper Pure Iron, Series B), manufactured by the American Rolling Mill Co. Sheet S 35 in Fig. 14 was the only reported failure for this group in 1918. Fig. 17 represents this group of sheets as they appear on the test rack at this inspection. All of these sheets have failed.

Figs. 18 to 23 inclusive represent the condition of Sheets X 29 to 42 inclusive (No. 22 Gage Low-Copper Pure Iron, Series B), manufactured by the Inland Steel Co. All of these sheets have failed.

Fig. 24 represents the condition of Sheets Z 6, 7 and 11 (No. 22 Gage Bessemer Steel, with varying copper contents, Series B), manufactured by the Youngstown Sheet and Tube Co. Sheet Z 11 was reported in April, 1918, as failed. Sheets Z 6 and 7 have now failed due to holes in lower ends.

Fig. 25 represents the condition of Sheets Z 422 to 424 inclusive (No. 22 Gage Open-hearth Steel, with varying copper contents, Series B), manufactured by the Youngstown Sheet and Tube Co. All of these sheets have failed.

All sheets that have failed prior to October 7, 1918, have been photographed and recorded.

Fig. 26 shows a general view of the sheets on the test rack at Annapolis, Md., as appearing at this inspection. No sheets have failed at this location.

Second Meeting.—The second meeting of the sub-committee was held at Fort Sheridan, Ill., on March 31, 1919, with Messrs. Aupperle, Buck, Fleming, McDonnell, Smith, Wheaton, Gibboney and Voorhees (*ex officio*) present, Mr. Cooper and the representative of the Bureau of Steam Engineering of the U. S. Navy Department being absent.

The Fort Sheridan sheets were inspected on March 31, 1919, followed by the Pittsburgh sheets on April 1, 1919. Mr. Cooper joined the sub-committee at Pittsburgh.

Members filing data sheets for these inspections are as follows:

Fort Sheridan.—Messrs. Aupperle, Buck, Fleming, McDonnell, Smith, Wheaton and Gibboney.

Pittsburgh.—Messrs. Aupperle, Buck, Cooper, Fleming, McDonnell, Smith, Wheaton and Gibboney.

The results of these inspections are shown in composite form as Tables III and IV, Plates III and IV.

Photographic records of all sheets exposed in Rows 3 to 7 inclusive at Pittsburgh were made on April 14, 1919. Sheets in Rows 1 and 2, with the exception of Z sheets in Row 2, which differ chemically from the Z sheets in Row 7, were not photographed, inasmuch as they are duplicates of sheets appearing in the back rows.

The following photographs of the Pittsburgh sheets show failures taking place since the October, 1918, inspection, representing an exposure period of 28 months.

Figs. 27 to 29 inclusive represent the condition of Sheets AA 25 to 30 inclusive (No. 16 Gage Bessemer Steel, Series A), having failed as evidenced by holes and ragged edges at lower ends.

Figs. 30 to 32 inclusive represent the condition of Sheets AA 50 to 56 inclusive (No. 16 Gage Bessemer Steel, Series A), having failed due to holes and ragged lower edges. These sheets were sand-blasted prior to placing on the test rack.

Figs. 33 to 36 inclusive represent the condition of Sheets D 30 and 31, 33 and 34, 35, and 39 and 40 (No. 22 Gage Low-Copper Pure Iron, Series A), having failed due to holes and ragged edges at lower ends. All of the D Sheets exposed at this location have now failed.

Figs. 37 and 38 represent the condition of Sheets E 29 to 31 inclusive and E 36 (No. 22 Gage Puddled Iron, Series A), having failed due to holes at lower ends of sheets.

Fig. 39 represents a general view of the sheets on the test rack at Pittsburgh, Pa., as appearing at this inspection.

There being no failures at the Fort Sheridan location, no photograph records were made.

Following the same general plan of presenting condensed results of various inspections, as appearing in the 1918 report of the sub-committee, tables have been prepared from the composite reports for the inspections made during the past year.

Tables V, VI, VII and VIII give in condensed form the results obtained by the averaging method for the condition of surfaces of sheets at Pittsburgh and Annapolis in October, 1918, and Fort Sheridan and Pittsburgh in April, 1919, respectively.

In view of the fact that the rate of corrosion for the Pittsburgh location has been decidedly more rapid than at Fort Sheridan and Annapolis, and that the Pittsburgh location only shows failures up to the last inspections in April, 1919, Table IX is presented as showing in condensed form the results obtained by the averaging method for the condition of surface texture of the sheets at Pittsburgh for all inspections. The conclusion to be drawn from this table is that at this location a smooth texture with a dark colored, tight adhering rust is coincident with a slow and uniform rate of corrosion.

Table X is presented as showing in condensed form the failures for the Pittsburgh location as recorded at all inspection periods, the lengths of exposure being 10, 16, 22 and 28 months respectively.

Figs. 40 to 44 inclusive represent the condition of groups of Sheets A 35 to 47 inclusive (No. 22 Gage Bessemer Steel, Series A), D 35, 36, 38, 39 and 40 (No. 22 Gage Low-Copper Pure Iron, Series A), O 29 to 36 inclusive (No. 22 Gage Low-Copper Open-hearth Steel, Series A), S 33 to 42 inclusive (No. 22 Gage

Tab

Date of Inspection *Oct. 7, 1918.*

ROW No. 1

Mark	Sheet No.	Texture									Color									Adherence								
		Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9
AA	31	VC	VC	VC	VC	VC		VC	M	VC	L	L	L	L	L		L	L	L	L	L	L	L	L		L	L	L
	32	VC	VC	VC	VC	VC		VC	C	VC	L	L	L	L	L		L	L	L	L	L	L	L	L		L	L	L
	33	VC	VC	VC	VC	VC		VC	M	VC	L	L	L	L	L		L	L	L	L	L	L	L	L		L	L	L
	34	VC	VC	VC	VC	VC		VC	V	VC	L	L	L	L	L		L	L	L	L	L	L	L	L		L	L	L
BB	18	M	S	M	S	M		M	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	19	M	S	M	S	M		M	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	20	M	M	M	S	M		M	S	M	D	D	D	D	D		D	D	D	T	M	T	T	T		T	T	T
	21	M	M	M	S	M		M	S	M	D	D	D	D	D		D	D	D	T	M	T	T	T		T	T	T
CC	15	M	M	M	M	M		M	M	C	M	M	M	D	M		M	D	M	T	M	T	T	T		T	L	L
	16	M	M	M	M	M		M	M	C	M	M	M	D	M		M	D	M	T	M	T	T	T		T	L	L
	17	M	M	M	M	M		M	M	C	M	M	M	D	M		M	D	M	T	M	T	T	T		T	L	L
	18	M	M	M	M	M		M	M	C	M	M	M	D	M		M	D	M	T	M	T	T	T		T	L	L
DD	25	M	C	C	C	C		M	M	C	M	M	M	M	M		M	D	M	T	L	T	L	L		T	L	L
	26	M	C	C	C	C		M	M	C	M	M	M	M	M		M	D	M	T	L	T	L	L		T	L	L
	27	M	C	C	C	C		M	M	C	M	M	M	M	M		M	D	M	T	L	T	L	L		T	L	L
	28	M	C	C	C	C		M	M	C	M	M	M	M	M		M	D	M	T	L	T	L	L		T	L	L
EE*	13	S	S	S	S	S		C	S	S	D	D	D	D	D		M	D	D	T	T	T	T	T		T	T	T
	14	S	S	S	S	S		C	S	S	D	D	D	D	D		M	D	D	T	T	T	T	T		T	T	T
	15	S	S	S	S	S		C	S	S	D	D	D	D	D		M	D	D	T	T	T	T	T		T	T	T
	16	S	S	S	S	S		C	S	S	D	D	D	D	D		M	D	D	T	T	T	T	T		T	T	T
HH	19	S	S	S	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	20	S	S	S	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	21	S	S	S	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	22	S	S	S	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
II	20	S	VS	S	VS	VS		VS	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	21	S	VS	S	VS	VS		VS	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	22	S	VS	S	VS	VS		VS	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	23	S	VS	S	VS	VS		VS	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
KK	6	S	VS	S	VS	VS		VS	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	7	S	VS	S	VS	VS		VS	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	8	S	VS	S	VS	VS		VS	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	22	S	VS	S	VS	VS		VS	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
MM*	29	M	S	M	M	M		M	S	M	M	M	M	D	M		M	D	D	T	T	T	T	T		T	T	T
	30	M	S	M	M	M		M	S	M	M	M	M	D	M		M	D	D	T	T	T	T	T		T	T	T
	31	M	S	M	M	M		M	S	M	M	M	M	D	M		M	D	D	T	T	T	T	T		T	T	T
	32	M	S	M	M	M		M	S	M	M	M	M	D	M		M	D	D	T	T	T	T	T		T	T	T
SS	29	C	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	L	L	L	L	L	L		L	L	L
	30	C	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	L	L	L	L	L	L		L	L	L
	31	C	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	L	L	L	L	L	L		L	L	L
	32	C	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	L	L	L	L	L	L		L	L	L
TT	29	S	S	S	VS	S		VS	VS	M	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	30	S	S	S	VS	S		VS	VS	M	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	31	S	S	S	VS	S		VS	VS	M	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	32	S	S	S	VS	S		VS	VS	M	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
UU	29	M	S	S	S	S		S	S	M	M	M	M	D	M		D	D	D	T	T	T	T	T		T	T	T
	30	M	S	S	S	S		S	S	M	M	M	M	D	M		D	D	D	T	T	T	T	T		T	T	T
	31	M	S	S	S	S		S	S	M	M	M	M	D	M		D	D	D	T	T	T	T	T		T	T	T
	32	M	S	S	S	S		S	S	M	M	M	M	D	M		D	D	D	T	T	T	T	T		T	T	T
VV	39	M	S	S	S	S		S	S	M	M	M	M	D	M		D	D	D	T	T	T	T	T		T	T	T
	40	M	S	S	S	S		S	S	M	M	M	M	D	M		D	D	D	T	T	T	T	T		T	T	T
	41	M	S	S	S	S		S	S	M	M	M	M	D	M		D	D	D	T	T	T	T	T		T	T	T
	42	M	S	S	S	S		S	S	M	M	M	M	D	M		D	D	D	T	T	T	T	T		T	T	T
XX	29	C	VC	C	VC	VC		VC	C	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	30	C	VC	C	VC	VC		VC	C	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	31	C	VC	C	VC	VC		VC	C	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	32	C	VC	C	VC	VC		VC	C	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
OO	25	C	C	C	M	C		C	M	C	M	L	M	M	M		M	D	M	L	L	L	L	L		T	L	T
	26	C	C	C	M	C		C	M	C	M	L	M	M	M		M	D	M	L	L	L	L	L		T	L	T
	27	C	C	C	M	C		C	M	C	M	L	M	M	M		M	D	M	L	L	L	L	L		T	L	T
	28	C	C	C	M	C		C	M	C	M	L	M	M	M		M	D	M	L	L	L	L	L		T	L	T
CCC	1	M	S	S	S	M		M	S	M	M	M	D	D	M		D	D	D	T	T	T	T	T		T	L	T
	2	M	S	S	S	M		M	S	M	M	M	D	D	M		D	D	D	T	T	T	T	T		T	L	T
	3	M	S	S	S	M		M	S	M	M	M	D	D	M		D	D	D	T	T	T	T	T		T	L	T
	4	M	S	S	S	M		M	S	M	M	M	D	D	M		D	D	D	T	T	T	T	T		T	L	T
YY	9	C	C	C	C	C		C	M	C	L	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	10	C	C	C	C	C		C	M	C	L	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	11	C	C	C	C	C		C	M	C	L	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	107	S	S	S	VS	S		S	VS	S	M	D	D	M	M		M	D	D	T	T	T	T	T		T	T	T
	310	VS	VS	VS	VS	VS		VS	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	311	VS	VS	VS	VS	VS		VS	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T

* Open Annealed.

ROW No. 2

Mark	Sheet No.	Texture									Color									Adherence								
		Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9
A	31	VC	VC	VC	VC	VC		VC	C	VC	M	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	32	VC	VC	VC	VC	VC		VC	C	VC	M	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	33	VC	VC	VC	VC	VC		VC	C	VC	M	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	34	VC	VC	VC	VC	VC		VC	C	VC	M	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
B	17	M	M	M	C	M		M	S	C	D	D	D	D	M		D	D	D	L	M	T	L	T		T	L	T
	18	M	M	M	C	M		M	S	C	D	D	D	D	M		D	D	D	L	M	T	L	T		T	L	T
	19	M	M	M	C	M		M	S	C	D	D	D	D	M		D	D	D	L	M	T	L	T		T	L	T
	20	M	M	M	C	M		M	S	C	D	D	D	D	M		D	D	D	L	M	T	L	T		T	L	T
C	11	M	M	M	M	M		M	M	C	M	M	D	D	D		D	D	D	T	M	T	T	T		T	L	T
	12	M	M	M	M	M		M	M	C	M	M	D	D	D		D	D	D	T	M	T	T	T		T	L	T
	13	M	M	M	M	M		M	M	C	M	M	D	D	D		D	D	D	T	M	T	T	T		T	L	T
	14	M	M	M	M	M		M	M	C	M	M	D	D	D		D	D	D	T	M	T	T	T		T	L	T
D	30	C	C	VC	VC	VC		VC	VC	VC	M	L	L	L	L		L	M	M	L	L	L	L	L		L	L	T
	31	C	C	VC	VC	VC		VC	VC	VC	M	L	L	L	L		L	M	M	L	L	L	L	L		L	L	T
	33	C	C	VC	VC	VC		VC	VC	VC	M	L	L	L	L		L	M	M	L	L	L	L	L		L	L	T
	34	C	C	VC	VC	VC		VC	VC	VC	M	L	L	L	L		L	M	M	L	L	L	L	L		L	L	T
E	25	S	M	M	M	M		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	L	T
	26	S	M	M	M	M		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	L	T
	27	S	M	M	M	M		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	L	T
	28	S	M	M	M	M		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	L	T
H	39	S	S	M	S	S		VS	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	L	T
	40	S	S	M	S	S		VS	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	L	T
	41	S	S	M	S	S		VS	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	L	T
	42	S	S	M	S	S		VS	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	L	T
I	38	S	VS	S	VS	S		VS	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	39	S	VS	S	VS	S		VS	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	40	S	VS	S	VS	S		VS	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	41	S	VS	S	VS	S		VS	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
K	33	S	VS	S	VS	S		VS	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	34	S	VS	S	VS	S		VS	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	35	S	VS	S	VS	S		VS	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	36	S	VS	S	VS	S		VS	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	29	M	M	S	S	M		M	S	M	D	D	M	D	M		M	D	D	T	T	T	T	T		T	T	T
	30	M	M	S	S	M		M	S	M	D	D	M	D	M		M	D	D	T	T	T	T	T		T	T	T
	31	M	M	S	S	M		S	S	M	D	D	M	D	M		M	D	D	T	T	T	T	T		T	T	T
	32	M	M	S	S	M		S	S	M	D	D	M	D	M		M	D	D	T	T	T	T	T		T	L	T
S	29	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	30	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	31	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	32	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
T	29	M	VS	S	VS	S		VS	S	M	M	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	30	M	VS	S	VS	S		VS	S	M	M	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	31	M	VS	S	VS	S		VS	S	M	M	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	32	M	VS	S	VS	S		VS	S	M	M	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
U	29	M	S	S	S	S		VS	S	M	M	D	D	D	M		D	D	D	T	T	T	T	T		T	L	T
	30	M	S	S	S	S		VS	S	M	M	D	D	D	M		D	D	D	T	T	T	T	T		T	L	T
	31	M	S	S	S	S		VS	S	M	M	D	D	D	M		D	D	D	T	T	T	T	T		T	L	T
	32	M	S	S	S	S		VS	S	M	M	D	D	D	M		D	D	D	T	T	T	T	T		T	L	T
V	29	M	S	S	S	S		S	S	M	M	D	D	D	M		D	D	D	T	T	T	T	T		T	L	T
	30	M	S	S	S	S		S	S	M	M	D	D	D	M		D	D	D	T	T	T	T	T		T	L	T
	31	M	S	S	S	S		S	S	M	M	D	D	D	M		D	D	D	T	T	T	T	T		T	L	T
	32	M	S	S	S	S		S	S	M	M	D	D	D	M		D	D	D	T	T	T	T	T		T	L	T
X	29	VC	VC	VC	VC	VC		VC	VC	C	L	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	30	VC	VC	VC	VC	VC		VC	VC	C	L	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	31	VC	VC	VC	VC	VC		VC	VC	C	L	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	32	VC	VC	VC	VC	VC		VC	VC	C	L	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
O	25	VC	VC		VC	VC		VC		VC	L	L		L	L		L		M	L	L		L	L		L		L
	26	VC	VC		VC	VC		VC		VC	L	L		L	L		L		M	L	L		L	L		L		L
	27	VC	VC		VC	VC		VC		VC	L	L		L	L		L		M	L	L		L	L		L		L
	28	VC	VC		VC	VC		VC		VC	L	L		L	L		L		M	L	L		L	L		L		L
Z	6	C	C	C	C	C		C	M	C	L	L	L	L	L		L	M	L	L	L	L	L	L		L	L	T
	7	C	C	C	C	C		C	M	C	L	L	L	L	L		L	M	L	L	L	L	L	L		L	L	T
	11	C	C	C	C	C		C	M	C	L	L	L	L	L		L	M	L	L	L	L	L	L		L	L	T
	111	VS	VS	S	S	S		VS	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	112	VS	VS	S	S	S		VS	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	113	VS	VS	S	S	S		VS	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	209	VS	VS	VS	S	S		VS	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	213	VS	VS	VS	S	S		VS	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	214	VS	VS	VS	S	S		VS	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	310	VS	VS	VS	S	S		VS	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T

ROW No. 3

Mark	Sheet No.	Texture									Color									Adherence								
		Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9
AA	25	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	26	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	27	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	28	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	29	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	30	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
AA◆	50	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	51	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	52	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	53	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	54	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	55	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	56	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
BB	22	C	C	M	M	M		M	M	C	D	M	D	D	M		D	D	D	T	M	T	T	T		T	L	T
	23	C	C	M	M	M		M	M	C	D	M	D	D	M		D	D	D	T	M	T	T	T		T	L	T
	24	C	C	M	M	M		M	M	C	D	M	D	D	M		D	D	D	T	M	T	T	T		T	L	T
	40	C	M	M	M	M		M	M	C	D	M	D	D	D		D	D	D	T	M	T	T	T		T	L	T
	41	C	M	M	M	M		M	M	C	D	M	D	D	D		D	D	D	T	M	T	T	T		T	L	T
BB◆	33	C	M	M	M	M		M	M	C	D	M	D	D	D		D	D	D	T	M	T	T	T		T	L	T
	34	C	M	M	M	M		M	M	C	D	M	D	D	D		D	D	D	T	M	T	T	T		T	L	T
	35	C	M	M	M	M		M	M	C	D	M	D	D	D		D	D	D	T	M	T	T	T		T	L	T
	36	C	M	M	M	M		M	M	C	D	M	D	D	D		D	D	D	T	M	T	T	T		T	L	T
	50	C	M	M	M	M		M	M	C	D	M	D	D	D		D	D	D	T	M	T	T	T		T	L	T
	51	C	M	M	M	M		M	M	C	D	M	D	D	D		D	D	D	T	M	T	T	T		T	L	T
	52	C	M	M	M	M		M	M	C	D	M	D	D	D		D	D	D	T	M	T	T	T		T	L	T
	53	C	M	M	M	M		M	M	C	D	M	D	D	D		D	D	D	T	M	T	T	T		T	L	T
CC	7	C	M	M	C	M		C	M	C	M	M	M	D	M		M	D	D	T	L	T	T	T		T	L	L
	19	C	M	M	C	M		C	M	C	M	M	M	D	M		M	D	D	T	L	T	T	T		T	L	L
CC◆	31	C	M	M	C	M		C	M	C	M	M	M	D	M		M	D	D	T	L	T	T	T		T	L	L
	32	C	M	M	C	M		C	M	C	M	M	M	D	M		M	D	D	T	L	T	T	T		T	L	L
	33	C	M	M	C	M		C	M	C	M	M	M	D	M		M	D	D	T	L	T	T	T		T	L	L
	34	C	M	M	C	M		C	M	C	M	M	M	D	M		M	D	D	T	L	T	T	T		T	L	L
	35	C	M	M	C	M		C	M	C	M	M	M	D	M		M	D	D	T	L	T	T	T		T	L	L
	36	C	M	M	C	M		C	M	C	M	M	M	D	M		M	D	D	T	L	T	T	T		T	L	L
DD	8	C	C	C	C	C		C	M	VC	M	M	M	L	M		M	D	D	T	L	TL	L	L		T	L	L
	9	C	C	C	C	C		C	M	VC	M	M	M	L	M		M	D	D	T	L	TL	L	L		T	L	L
	10	C	C	C	C	C		C	M	VC	M	M	M	L	M		M	D	D	T	L	TL	L	L		T	L	L
	29	C	C	C	C	C		C	M	VC	M	M	M	L	M		M	D	M	T	L	TL	L	L		T	L	L
	30	C	C	C	C	C		C	M	VC	M	M	M	L	M		M	D	M	T	L	TL	L	L		T	L	L
	31	C	C	C	C	C		C	M	VC	M	M	M	L	M		M	D	M	T	L	TL	L	L		T	L	L
DD◆	47	C	C	C	C	C		C	M	C	M	M	M	L	M		M	D	D	T	L	TL	L	L		T	L	L
	48	C	C	C	C	C		C	M	C	M	M	M	L	M		M	D	D	T	L	TL	L	L		T	L	L
	49	C	C	C	C	C		C	M	C	M	M	M	L	M		M	D	D	T	L	TL	L	L		T	L	L
	54	C	C	C	C	C		C	M	C	M	M	M	L	M		M	D	D	T	L	TL	L	L		T	L	L
	55	C	C	C	C	C		C	M	C	M	M	M	L	M		M	D	D	T	L	TL	L	L		T	L	L
	56	C	C	C	C	C		C	M	C	M	M	M	L	M		M	D	D	T	L	TL	L	L		T	L	L
	57	C	C	C	C	C		C	M	C	M	M	M	L	M		M	D	D	T	L	TL	L	L		T	L	L
	58	C	C	C	C	C		C	M	C	M	M	M	L	M		M	D	D	T	L	TL	L	L		T	L	L
EE†	17	S	M	S	S	S		S	S	M	D	M	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	18	S	M	S	S	S		S	S	M	D	M	D	D	D		D	D	D	T	T	T	T	T		T	T	T
EE◆†	31	S	M	S	S	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	32	S	M	S	S	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	33	S	M	S	S	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	34	S	M	S	S	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	35	S	M	S	S	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	36	S	M	S	S	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
HH	23	S	S	S	S	S		S	VS	M	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	24	S	S	S	S	S		S	VS	M	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	25	S	S	S	S	S		S	VS	M	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	26	S	S	S	S	S		S	VS	M	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
HH◆	43	S	S	S	S	S		S	VS	S	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	44	S	S	S	S	S		S	VS	S	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	45	S	S	S	S	S		S	VS	S	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	46	S	S	S	S	S		S	VS	S	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	47	S	S	S	S	S		S	VS	S	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	48	S	S	S	S	S		S	VS	S	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	49	S	S	S	S	S		S	VS	S	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
II	24	S	VS	S	S	S		VS	VS	S	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	26	S	VS	S	S	S		VS	VS	S	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	27	S	VS	S	S	S		VS	VS	S	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	28	S	VS	S	S	S		VS	VS	S	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	29	S	VS	S	S	S		VS	VS	S	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T

◆ Sand Blasted.

† Open Annealed.

ROW No. 4

Mark	Sheet No.	Texture									Color								
		Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9
II◆	48	S	VS	S	VS	VS		S	S	S	D	D	D	D	D		D	D	D
	49	S	VS	S	VS	VS		S	S	S	D	D	D	D	D		D	D	D
	50	S	VS	S	VS	VS		S	S	S	D	D	D	D	D		D	D	D
	51	S	VS	S	VS	VS		S	S	S	D	D	D	D	D		D	D	D
	52	S	VS	S	VS	VS		S	S	S	D	D	D	D	D		D	D	D
	53	S	VS	S	VS	VS		S	S	S	D	D	D	D	D		D	D	D
	54	S	VS	S	VS	VS		S	S	S	D	D	D	D	D		D	D	D
	56	S	VS	S	VS	VS		S	S	S	D	D	D	D	D		D	D	D
	58	S	VS	S	VS	VS		S	S	S	D	D	D	D	D		D	D	D
KK	28	S	S	S	S	S		S	VS	S	D	D	D	D	D		D	D	D
	29	S	S	S	S	S		S	VS	S	D	D	D	D	D		D	D	D
	30	S	S	S	S	S		S	VS	S	D	D	D	D	D		D	D	D
	31	S	S	S	S	S		S	VS	S	D	D	D	D	D		D	D	D
	32	S	S	S	S	S		S	VS	S	D	D	D	D	D		D	D	D
	33	S	S	S	S	S		S	VS	S	D	D	D	D	D		D	D	D
	34	S	S	S	S	S		S	VS	S	D	D	D	D	D		D	D	D
KK◆	51	S	S	S	S	S		S	VS	M	D	D	D	D	D		D	D	D
	52	S	S	S	S	S		S	VS	M	D	D	D	D	D		D	D	D
	53	S	S	S	S	S		S	VS	M	D	D	D	D	D		D	D	D
	54	S	S	S	S	S		S	VS	M	D	D	D	D	D		D	D	D
	55	S	S	S	S	S		S	VS	M	D	D	D	D	D		D	D	D
	56	S	S	S	S	S		S	VS	M	D	D	D	D	D		D	D	D
	57	S	S	S	S	S		S	VS	M	D	D	D	D	D		D	D	D
	58	S	S	S	S	S		S	VS	M	D	D	D	D	D		D	D	D
MM†	33	M	M	M	C	C		M	M	C	M	D	D	D	M		M	D	D
	34	M	M	M	C	C		M	M	C	M	D	D	D	M		M	D	D
	35	M	M	M	C	C		M	M	C	M	D	D	D	M		M	D	D
	36	M	M	M	C	C		M	M	C	M	D	D	D	M		M	D	D
	37	M	M	M	C	C		M	M	C	M	D	D	D	M		M	D	D
	38	M	M	M	C	C		M	M	C	M	D	D	D	M		M	D	D
	39	M	M	M	C	C		M	M	C	M	D	D	D	M		M	D	D
	40	M	M	M	C	C		M	M	C	M	D	D	D	M		M	D	D
	41	M	M	M	C	C		M	M	C	M	D	D	D	M		M	D	D
	42	M	M	M	C	C		M	M	C	M	D	D	D	M		M	D	D
SS	33	C	VC	VC	VC	VC		VC	VC	VC	L	L	M	L	L		L	M	M
	34	C	VC	VC	VC	VC		VC	VC	VC	L	L	M	L	L		L	M	M
	35	C	VC	VC	VC	VC		VC	VC	VC	L	L	M	L	L		L	M	M
	36	C	VC	VC	VC	VC		VC	VC	VC	L	L	M	L	L		L	M	M
	37	C	VC	VC	VC	VC		VC	VC	VC	L	L	M	L	L		L	M	M
	38	C	VC	VC	VC	VC		VC	VC	VC	L	L	M	L	L		L	D	M
	39	C	VC	VC	VC	VC		VC	VC	VC	L	L	M	L	L		L	D	M
	40	C	VC	VC	VC	VC		VC	VC	VC	L	L	M	L	L		L	D	M
	41	C	VC	VC	VC	VC		VC	VC	VC	L	L	M	L	L		L	D	M
	42	C	VC	VC	VC	VC		VC	VC	VC	L	L	M	L	L		L	D	M
TT	33	S	S	S	S	S		S	S	M	D	D	D	D	D		D	D	D
	34	S	S	S	S	S		S	S	M	D	D	D	D	D		D	D	D
	35	S	S	S	S	S		S	S	M	D	D	D	D	D		D	D	D
	36	S	S	S	S	S		S	S	M	D	D	D	D	D		D	D	D
	37	S	S	S	S	S		S	S	M	D	D	D	D	D		D	D	D
	38	S	S	S	S	S		S	S	M	D	D	D	D	D		D	D	D
	39	S	S	S	S	S		S	S	M	D	D	D	D	D		D	D	D
	40	S	S	S	S	S		S	S	M	D	D	D	D	D		D	D	D
	41	S	S	S	S	S		S	S	M	D	D	D	D	D		D	D	D
	42	S	S	S	S	S		S	S	M	D	D	D	D	D		D	D	D
UU	33	S	S	S	S	M		S	VS	M	M	D	D	D	D		D	D	D
	34	S	S	S	S	M		S	VS	M	M	D	D	D	D		D	D	D
	35	S	S	S	S	M		S	VS	M	M	D	D	D	D		D	D	D
	36	S	S	S	S	M		S	VS	M	M	D	D	D	D		D	D	D
	37	S	S	S	S	M		S	VS	M	M	D	D	D	D		D	D	D
	38	S	S	S	S	M		S	VS	M	M	D	D	D	D		D	D	D
	39	S	S	S	S	M		S	VS	M	M	D	D	D	D		D	D	D
	40	S	S	S	S	M		S	VS	M	M	D	D	D	D		D	D	D
	41	S	S	S	S	M		S	VS	M	M	D	D	D	D		D	D	D
	42	S	S	S	S	M		S	VS	M	M	D	D	D	D		D	D	D
VV	43	S	S	S	S	S		S	VS	M	D	D	D	D	M		D	D	D
	44	S	S	S	S	S		S	VS	M	D	D	D	D	M		D	D	D
	45	S	S	S	S	S		S	VS	M	D	D	D	D	M		D	D	D
	46	S	S	S	S	S		S	VS	M	D	D	D	D	M		D	D	D
	47	S	S	S	S	S		S	VS	M	D	D	D	D	M		D	D	D
	48	S	S	S	S	S		S	VS	M	D	D	D	D	M		D	D	D
	49	S	S	S	S	S		S	VS	M	D	D	D	D	M		D	D	D
	50	S	S	S	S	S		S	VS	M	D	D	D	D	M		D	D	D
	51	S	S	S	S	S		S	VS	M	D	D	D	D	M		D	D	D

◆ Sand Blasted.

† Open Annealed.

CONDITION OF RUST.

Texture	Color	Adherence
VS—Very Smooth	L—Light	T—Tight
S—Smooth	M—Medium	L—Loose
M—Medium	D—Dark	
C—Coarse		
VC—Very Coarse		

— INSPECTION COMMITTEE —

J.H. Gibboney, Chairman — Norfolk & Western Ry. Co.
J.A. Aupperlé — American Rolling Mill Co.
D.M. Buck — American Sheet & Tin Plate Co.
W.A. Cooper — Alan Wood Iron & Steel Co.
W.R. Fleming — The Andrews Steel Co.
D.J. McAdam, Jr. — U.S. Navy, Bureau Steam Engineering.
M.E. Mc.Donnell — Pennsylvania Railroad Co.
H.E. Smith — New York Central Railroad Co.
F.B. Wheaton — U.S. Army, Quartermaster's Corps.

— AUPPERLE —

Sheets	A	31 to 34 incl.	Lower Portion gone to Extent of 15%.	Sheets	D	36	2" Hole
"	D	30	One Hole 1"x6".	"	D	38	3" "
"	S	29, 30 & 31	2" Hole.	"	E	32	4" "
"	S	32	6" " .	"	E	36	2" "
"	X	29 & 30	3" " .	"	I	50	2" "
"	X	31	1" " .	"	S	33	1" "
"	X	32	12" " .	"	S	34	12" "
"	O	25 to 28 incl.	Complete Failure.	"	S	35	10" "
"	Z	6	12" Hole.	"	S	36	5" "
"	Z	7 & 11	Gone from Bottom.	"	S	37 to 40 incl.	6" "
"	A	35 to 47 incl.	Complete Failure.	"	S	41	8" "
"	B	37	2" Hole.	"	S	42	4" "
"	B	38	2" " Accidental.	"	Y	40	2" "

Table I.—Results of Inspection of Corrosion Test Sheets, at Pittsburgh, Pa., October 7, 1918.

AMERICAN SOCIETY FOR TESTING MATERIALS

COMMITTEE A-5 ON CORROSION OF IRON AND STEEL
TESTS OF UNCOATED SHEETS
PITTSBURGH, PA.

EXPOSED DECEMBER 12, 1916

7, 1918.

Color: 7 McDonnell	8 Smith	9 Wheaton	Adherence: 1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton
L	M	M	L	L	L	L	L		L	L	L
L	M	M	L	L	L	L	L		L	L	L
L	M	M	L	L	L	L	L		L	L	L
L	M	M	L	L	L	L	L		L	L	L
L	M	M	L	L	L	L	L		L	L	L
L	M	M	L	L	L	L	L		L	L	L
L	M	M	L	L	L	L	L		L	L	L
L	M	M	L	L	L	L	L		L	L	L
L	M	M	L	L	L	L	L		L	L	L
L	M	M	L	L	L	L	L		L	L	L
L	M	M	L	L	L	L	L		L	L	L
L	M	M	L	L	L	L	L		L	L	L
L	M	M	L	L	L	L	L		L	L	L
D	D	D	T	M	T	T	T		T	L	T
D	D	D	T	M	T	T	T		T	L	T
D	D	D	T	M	T	T	T		T	L	T
D	D	D	T	M	T	T	T		T	L	T
D	D	D	T	M	T	T	T		T	L	T
D	D	D	T	M	T	T	T		T	L	T
D	D	D	T	M	T	T	T		T	L	T
D	D	D	T	M	T	T	T		T	L	T
D	D	D	T	M	T	T	T		T	L	T
D	D	D	T	M	T	T	T		T	L	T
D	D	D	T	M	T	T	T		T	L	T
D	D	D	T	M	T	T	T		T	L	T
D	D	D	T	M	T	T	T		T	L	T
M	D	D	T	L	T	T	T		T	L	L
M	D	D	T	L	T	T	T		T	L	L
M	D	D	T	L	T	T	T		T	L	L
M	D	D	T	L	T	T	T		T	L	L
M	D	D	T	L	T	T	T		T	L	L
M	D	D	T	L	T	T	T		T	L	L
M	D	D	T	L	T	T	T		T	L	L
M	D	D	T	L	T	T	T		T	L	L
M	D	D	T	L	TL	L	L		T	L	L
M	D	D	T	L	TL	L	L		T	L	L
M	D	D	T	L	TL	L	L		T	L	L
M	D	M	T	L	TL	L	L		T	L	L
M	D	M	T	L	TL	L	L		T	L	L
M	D	M	T	L	TL	L	L		T	L	L
M	D	D	T	L	TL	L	L		T	L	L
M	D	D	T	L	TL	L	L		T	L	L
M	D	D	T	L	TL	L	L		T	L	L
M	D	D	T	L	TL	L	L		T	L	L
M	D	D	T	L	TL	L	L		T	L	L
M	D	D	T	L	TL	L	L		T	L	L
M	D	D	T	L	TL	L	L		T	L	L
M	D	D	T	L	TL	L	L		T	L	L
D	D	D	T	T	T	T	T		T	T	T
D	D	D	T	T	T	T	T		T	T	T
D	D	D	T	T	T	T	T		T	T	T
D	D	D	T	T	T	T	T		T	T	T
D	D	D	T	T	T	T	T		T	T	T
D	D	D	T	T	T	T	T		T	T	T
D	D	D	T	T	T	T	T		T	T	T
D	D	D	T	T	T	T	T		T	T	T
D	D	D	T	T	T	T	T		T	T	T
D	D	D	T	T	T	T	T		T	T	T
D	D	D	T	T	T	T	T		T	T	T
D	D	D	T	T	T	T	T		T	T	T
D	D	D	T	T	T	T	T		T	T	T
D	D	D	T	T	T	T	T		T	T	T
D	D	D	T	T	T	T	T		T	T	T
D	D	D	T	T	T	T	T		T	T	T
D	D	D	T	T	T	T	T		T	T	T
D	D	D	T	T	T	T	T		T	T	T
D	D	D	T	T	T	T	T		T	T	T
D	D	D	T	T	T	T	T		T	T	T
D	D	D	T	T	T	T	T		T	T	T
D	D	D	T	T	T	T	T		T	T	T
D	D	D	T	T	T	T	T		T	T	T
D	D	D	T	T	T	T	T		T	T	T

ROW No. 4

Mark	Sheet No.	Texture: 1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton	Color: 1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton	Adherence: 1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton
II♦	48	S	VS	S	VS	VS		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	49	S	VS	S	VS	VS		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	50	S	VS	S	VS	VS		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	51	S	VS	S	VS	VS		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	52	S	VS	S	VS	VS		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	53	S	VS	S	VS	VS		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	54	S	VS	S	VS	VS		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	55	S	VS	S	VS	VS		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	56	S	VS	S	VS	VS		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
KK	28	S	S	S	S	S		S	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	29	S	S	S	S	S		S	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	30	S	S	S	S	S		S	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	31	S	S	S	S	S		S	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	32	S	S	S	S	S		S	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	33	S	S	S	S	S		S	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	34	S	S	S	S	S		S	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
KK♦	51	S	S	S	S	S		S	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	52	S	S	S	S	S		S	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	53	S	S	S	S	S		S	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	54	S	S	S	S	S		S	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	55	S	S	S	S	S		S	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	56	S	S	S	S	S		S	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	57	S	S	S	S	S		S	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	58	S	S	S	S	S		S	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
MM†	33	M	M	M	C	C		M	M	C	M	D	D	D	M		M	D	D	L	L	T	L	L		T	L	T
	34	M	M	M	C	C		M	M	C	M	D	D	D	M		M	D	D	L	L	T	L	L		T	L	T
	35	M	M	M	C	C		M	M	C	M	D	D	D	M		M	D	D	L	L	T	L	L		T	L	T
	36	M	M	M	C	C		M	M	C	M	D	D	D	M		M	D	D	L	L	T	L	L		T	L	T
	37	M	M	M	C	C		M	M	C	M	D	D	D	M		M	D	D	L	L	T	L	L		T	L	T
	38	M	M	M	C	C		M	M	C	M	D	D	D	M		M	D	D	L	L	T	L	L		T	L	T
	39	M	M	M	C	C		M	M	C	M	D	D	D	M		M	D	D	L	L	T	L	L		T	L	T
	40	M	M	M	C	C		M	M	C	M	D	D	D	M		M	D	D	L	L	T	L	L		T	L	T
	41	M	M	M	C	C		M	M	C	M	D	D	D	M		M	D	D	L	L	T	L	L		T	L	T
	42	M	M	M	C	C		M	M	C	M	D	D	D	M		M	D	D	L	L	T	L	L		T	L	T
SS	33	C	VC	VC	VC	VC		VC	VC	VC	L	L	M	L	L		L	M	M	L	L	L	L	L		L	L	L
	34	C	VC	VC	VC	VC		VC	VC	VC	L	L	M	L	L		L	M	M	L	L	L	L	L		L	L	L
	35	C	VC	VC	VC	VC		VC	VC	VC	L	L	M	L	L		L	M	M	L	L	L	L	L		L	L	L
	36	C	VC	VC	VC	VC		VC	VC	VC	L	L	M	L	L		L	M	M	L	L	L	L	L		L	L	L
	37	C	VC	VC	VC	VC		VC	VC	VC	L	L	M	L	L		L	M	M	L	L	L	L	L		L	L	L
	38	C	VC	VC	VC	VC		VC	VC	VC	L	L	M	L	L		L	D	M	L	L	L	L	L		L	L	L
	39	C	VC	VC	VC	VC		VC	VC	VC	L	L	M	L	L		L	D	M	L	L	L	L	L		L	L	L
	40	C	VC	VC	VC	VC		VC	VC	VC	L	L	M	L	L		L	D	M	L	L	L	L	L		L	L	L
	41	C	VC	VC	VC	VC		VC	VC	VC	L	L	M	L	L		L	D	M	L	L	L	L	L		L	L	L
	42	C	VC	VC	VC	VC		VC	VC	VC	L	L	M	L	L		L	D	M	L	L	L	L	L		L	L	L
TT	33	S	S	S	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	34	S	S	S	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	35	S	S	S	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	36	S	S	S	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	37	S	S	S	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	38	S	S	S	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	39	S	S	S	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	40	S	S	S	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	41	S	S	S	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	42	S	S	S	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
UU	33	S	S	S	S	M		S	VS	M	M	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	34	S	S	S	S	M		S	VS	M	M	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	35	S	S	S	S	M		S	VS	M	M	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	36	S	S	S	S	M		S	VS	M	M	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	37	S	S	S	S	M		S	VS	M	M	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	38	S	S	S	S	M		S	VS	M	M	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	39	S	S	S	S	M		S	VS	M	M	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	40	S	S	S	S	M		S	VS	M	M	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	41	S	S	S	S	M		S	VS	M	M	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	42	S	S	S	S	M		S	VS	M	M	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
VV	43	S	S	S	S	S		S	VS	M	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	44	S	S	S	S	S		S	VS	M	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	45	S	S	S	S	S		S	VS	M	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	46	S	S	S	S	S		S	VS	M	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	47	S	S	S	S	S		S	VS	M	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	48	S	S	S	S	S		S	VS	M	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	49	S	S	S	S	S		S	VS	M	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	50	S	S	S	S	S		S	VS	M	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	51	S	S	S	S	S		S	VS	M	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T

ROW No.

Mark	Sheet No.	Texture: 1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton	Color: 1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton	Adherence: 1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton
XX	33	C	C	C	VC	C		C	C	VC	M	M	M	L	M		L	M	M	L	L	L	L	L		L	L	T
	34	C	C	C	VC	C		C	C	VC	M	M	M	L	M		L	M	M	L	L	L	L	L		L	L	T
	35	C	C	C	VC	C		C	C	VC	M	M	M	L	M		L	M	M	L	L	L	L	L		L	L	T
	36	C	C	C	VC	C		C	C	VC	M	M	M	L	M		L	M	M	L	L	L	L	L		L	L	T
	37	C	C	C	VC	C		C	C	VC	M	M	M	L	M		L	M	M	L	L	L	L	L		L	L	T
	38	C	C	C	VC	C		C	C	VC	M	M	M	L	M		L	M	M	L	L	L	L	L		L	L	T
	39	C	C	C	VC	C		C	C	VC	M	M	M	L	M		L	M	M	L	L	L	L	L		L	L	T
	40	C	C	C	VC	C		C	C	VC	M	M	M	L	M		L	M	M	L	L	L	L	L		L	L	T
	41	C	C	C	VC	C		C	C	VC	M	M	M	L	M		L	M	M	L	L	L	L	L		L	L	T
	42	C	C	C	VC	C		C	C	VC	M	M	M	L	M		L	M		L	L	L		L		L	L	T
ZZ	208	VS	VS	VS	S	S		VS	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	209	VS	VS	VS	S	S		VS	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	213	VS	VS	VS	S	S		VS	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	314	VS	VS	VS	S	S		VS	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	426	VS	C	S	C	C		C	M	C	D	M	M	L	M		M	D	D	T	L	L	L	L		L	T	T
	427	VS	C	S	C	C		C	M	C	D	M	M	L	M		M	D	D	T	L	L	L	L		L	T	T
	507	VS	VS	VS	S	S		S	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	510	VS	VS	VS	S	S		S	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	509	VS	VS	VS	S	S		S	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	612	VS	VS	VS	S	S		S	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	614	VS	VS	VS	S	S		S	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	615	VS	VS	VS	S	S		S	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	714	VS	VS	VS	S	S		S	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	715	VS	VS	VS	S	S		S	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
OO	29	C	C	C	VC	C		C	M	C	M	M	M	L	L		L	D	D	L	L	L	L	L		L	L	T
	30	C	C	C	VC	C		C	M	C	M	M	M	L	L		L	D	D	L	L	L	L	L		L	L	T
	31	C	C	C	VC	C		C	M	C	M	M	M	L	L		L	D	D	L	L	L	L	L		L	L	T
	32	C	C	C	VC	C		C	M	C	M	M	M	L	L		L	D	D	L	L	L	L	L		L	L	T
	33	C	C	C	VC	C		C	M	C	M	M	M	L	L		L	D	D	L	L	L	L	L		L	L	T
	34	C	C	C	VC	C		C	M	C	M	M	M	L	L		L	D	D	L	L	L	L	L		L	L	T
	35	C	C	C	VC	C		C	M	C	M	M	M	L	L		L	D	D	L	L	L	L	L		L	L	T
	36	C	C	C	VC	C		C	M	C	M	M	M	L	L		L	D	D	L	L	L	L	L		L	L	T
OOO	5	M	M	M	M	M		S	S	M	D	D	M	D	D		D	D	D	T	M	T	T	T		T	T	T
	6	M	M	M	M	M		S	S	M	D	D	M	D	D		D	D	D	T	M	T	T	T		T	T	T
	7	M	M	M	M	M		S	S	M	D	D	M	D	D		D	D	D	T	M	T	T	T		T	T	T
	8	M	M	M	M	M		S	S	M	D	D	M	D	D		D	D	D	T	M	T	T	T		T	T	T
	9	M	M	M	M	M		S	S	M	D	D	M	D	D		D	D	D	T	M	T	T	T		T	T	T
	10	M	M	M	M	M		S	S	M	D	D	M	D	D		D	D	D	T	M	T	T	T		T	T	T
	11	M	M	M	M	M		S	S	M	D	D	M	D	D		D	D	D	T	M	T	T	T		T	T	T
	12	M	M	M	M	M		S	S	M	D	D	M	D	D		D	D	D	T	M	T	T	T		T	T	T
A	35	VC	VC	VC	VC	VC		VC	C	VC	M	L	M	L	L		L	M	D	L	L	L	L	L		L	L	L
	36	VC	VC	VC	VC	VC		VC	C	VC	M	L	M	L	L		L	M	D	L	L	L	L	L		L	L	L
	37	VC	VC	VC	VC	VC		VC	C	VC	M	L	M	L	L		L	M	D	L	L	L	L	L		L	L	L
	38	VC	VC	VC	VC	VC		VC	C	VC	M	L	M	L	L		L	M	D	L	L	L	L	L		L	L	L
	39	VC	VC	VC	VC	VC		VC	C	VC	M	L	M	L	L		L	M	D	L	L	L	L	L		L	L	L
	40	VC	VC	VC	VC	VC		VC	C	VC	M	L	M	L	L		L	M	D	L	L	L	L	L		L	L	L
	41	VC	VC	VC	VC	VC		VC	C	VC	M	L	M	L	L		L	M	D	L	L	L	L	L		L	L	L
	42	VC	VC	VC	VC	VC		VC	C	VC	M	L	M	L	L		L	M	D	L	L	L	L	L		L	L	L
	43	VC	VC	VC	VC	VC		VC	C	VC	M	L	M	L	L		L	M	D	L	L	L	L	L		L	L	L
	44	VC	VC	VC	VC	VC		VC	C	VC	M	L	M	L	L		L	M	D	L	L	L	L	L		L	L	L
	45	VC	VC	VC	VC	VC		VC	C	VC	M	L	M	L	L		L	M	D	L	L	L	L	L		L	L	L
	46	VC	VC	VC	VC	VC		VC	C	VC	M	L	M	L	L		L	M	D	L	L	L	L	L		L	L	L
	47	VC	VC	VC	VC	VC		VC	C	VC	M	L	M	L	L		L	M	D	L	L	L	L	L		L	L	L
B	21	VS	S	S	M	S		S	VS	M	M	D	M	D	D		D	D	D	T	T	T	T	T		T	T	T
	22	VS	S	S	M	S		S	VS	M	M	D	M	D	D		D	D	D	T	T	T	T	T		T	T	T
	23	VS	S	S	M	S		S	VS	M	M	D	M	D	D		D	D	D	T	T	T	T	T		T	T	T
	34	VS	S	S	M	S		S	VS	M	M	D	M	D	D		D	D	D	T	T	T	T	T		T	T	T
	35	VS	M	S	M	S		M	S	M	M	D	M	D	D		D	D	D	T	L	T	T	T		T	T	T
	36	VS	M	S	M	S		S	VS	M	M	D	M	D	D		D	D	D	T	L	T	T	T		T	T	T
	37	VS	M	S	M	S		M	VS	M	M	D	M	D	D		D	D	D	T	L	T	T	T		T	T	T
	38	VS	M	S	M	S		M	VS	M	M	D	M	D	D		D	D	D	T	L	T	T	T		T	T	T
	39	VS	S	S	M	S		M	VS	M	M	D	M	D	D		D	D	D	T	T	T	T	T		T	T	T
C	20	S	M	S	M	M		M	VS	M	D	M	M	D	M		D	D	D	T	L	T	T	T		T	T	T
	21	S	M	S	M	M		M	VS	M	D	M	M	D	M		D	D	D	T	L	T	T	T		T	T	T
	22	S	M	S	M	M		M	VS	M	D	M	M	D	M		D	D	D	T	L	T	T	T		T	T	T
	32	S	M	S	M	M		M	VS	M	D	M	M	D	M		D	D	D	T	L	T	T	T		T	T	T
	33	S	M	S	M	M		M	VS	M	D	M	M	D	M		D	D	D	T	L	T	T	T		T	T	T
	34	S	M	S	M	M		M	VS	M	D	M	M	D	M		D	D	D	T	L	T	T	T		T	T	T
	35	S	M	S	M	M		M	VS	M	D	M	M	D	M		D	D	D	T	L	T	T	T		T	T	T

ROW No. 6

Mark	Sheet No.	Texture: 1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton	Color: 1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton	Adherence: 1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton
D	35	C	C	C	C	C		C	C	C	T	M	M	L	L		M	M	M	L	L	L	L	L		L	L	T
	36	C	C	C	C	C		C	C	C	T	M	M	L	L		M	M	M	L	L	L	L	L		L	L	T
	38	C	C	C	C	C		C	C	C	T	M	M	L	L		M	M	M	L	L	L	L	L		L	L	T
	39	C	C	C	C	C		C	C	C	T	M	M	L	L		M	M	M	L	L	L	L	L		L	L	T
	40	C	C	C	C	C		C	C	C	T	M	M	L	L		M	M	M	L	L	L	L	L		L	L	T
E	29	M	M	S	S	M		S	S	M	D	D	D	D	D		D	D	D	T	M	T	T	T		T	T	T
	30	M	M	S	S	M		M	S	M	D	D	D	D	D		D	D	D	T	M	T	T	T		T	T	T
	31	M	M	S	S	M		M	S	M	D	D	D	D	D		D	D	D	T	M	T	T	T		T	T	T
	32	M	M	S	S	M		M	S	M	D	D	D	D	D		D	D	D	T	M	T	T	T		T	T	T
	33	M	M	S	S	M		M	S	M	D	D	D	D	D		D	D	D	T	M	T	T	T		T	T	T
	34	M	M	S	S	M		M	S	M	D	D	D	D	D		D	D	D	T	M	T	T	T		T	T	T
	35	M	M	S	S	M		M	S	M	D	D	D	D	D		D	D	D	T	M	T	T	T		T	T	T
	36	M	M	S	S	M		M	S	M	D	D	D	D	D		D	D	D	T	M	T	T	T		T	T	T
H	43	S	S	S	S	S		S	VS	M	M	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	45	S	S	S	S	S		S	VS	M	M	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	47	S	S	S	S	S		S	VS	M	M	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	49	S	S	S	S	S		S	VS	M	M	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	50	S	S	S	S	S		S	VS	M	M	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	53	S	S	S	S	S		S	VS	M	M	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	54	S	S	S	S	S		S	VS	M	M	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	55	S	S	S	S	S		S	VS	M	M	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
I	42	VS	VS	VS	S	VS		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	43	VS	VS	VS	S	VS		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	44	VS	VS	VS	S	VS		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	45	VS	VS	VS	S	VS		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	46	VS	VS	VS	S	VS		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	47	VS	VS	VS	S	VS		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	48	VS	VS	VS	S	VS		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	49	VS	VS	VS	S	VS		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	50	VS	VS	VS	S	VS		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	51	VS	VS	VS	S	VS		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	52	VS	VS	VS	S	VS		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	53	VS	VS	VS	S	VS		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	54	VS	VS	VS	S	VS		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	55	VS	VS	VS	S	VS		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
K	37	S	VS	VS	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	38	S	VS	VS	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	39	S	VS	VS	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	40	S	VS	VS	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	41	S	VS	VS	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	42	S	VS	VS	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	43	S	VS	VS	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	44	S	VS	VS	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	45	S	VS	VS	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	46	S	VS	VS	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	47	S	VS	VS	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	48	S	VS	VS	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	33	S	S	S	S	S		S	S	M	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	34	S	S	S	S	S		S	S	M	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	35	S	S	S	S	S		S	S	M	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	36	S	S	S	S	S		S	S	M	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	37	S	S	S	S	S		S	S	M	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	38	S	S	S	S	S		S	S	M	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	39	S	S	S	S	S		S	S	M	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	40	S	S	S	S	S		S	S	M	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	41	S	S	S	S	S		S	S	M	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
	42	S	S	S	S	S		S	S	M	D	D	D	D	M		D	D	D	T	T	T	T	T		T	T	T
N	33	VC	VC	VC	VC	VC		VC	VC	VC	M	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	34	VC	VC	VC	VC	VC		VC	VC	VC	M	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	35	VC	VC	VC	VC	VC		VC	VC	VC	M	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	36	VC	VC	VC	VC	VC		VC	VC	VC	M	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	37	VC	VC	VC	VC	VC		VC	VC	VC	M	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	38	VC	VC	VC	VC	VC		VC	VC	VC	M	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	39	VC	VC	VC	VC	VC		VC	VC	VC	M	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	40	VC	VC	VC	VC	VC		VC	VC	VC	M	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	11	VC	VC	VC	VC	VC		VC	VC	VC	M	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L
	42	VC	VC	VC	VC	VC		VC	VC	VC	M	L	L	L	L		L	M	M	L	L	L	L	L		L	L	L

ROW No. 7

Mark	Sheet No.	Texture: 1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton	Color: 1 Aupperle	2 Buck
T	33	VS	S	S	S	S		S	VS	M	D	D
	34	VS	S	S	S	S		S	VS	M	D	D
	35	VS	S	S	S	S		M	VS	M	D	D
	36	VS	S	S	S	S		S	VS	M	D	D
	37	VS	S	S	S	S		S	VS	M	D	D
	38	VS	S	S	S	S		S	VS	M	D	D
	39	VS	S	S	S	S		S	VS	M	D	D
	40	VS	S	S	S	S		S	VS	M	D	D
	41	VS	S	S	S	S		M	VS	M	D	D
	42	VS	S	S	S	S		S	VS	M	D	D
U	33	S	S	S	S	S		M	VS	M	D	D
	34	S	S	S	S	S		M	VS	M	D	D
	35	S	S	S	S	S		M	VS	M	D	D
	36	S	S	S	S	S		M	VS	M	D	D
	37	S	S	S	S	S		M	VS	M	D	D
	38	S	S	S	S	S		M	VS	M	D	D
	39	S	S	S	S	S		M	VS	M	D	D
	40	S	S	S	S	S		M	VS	M	D	D
	41	S	S	S	S	S		M	VS	M	D	D
	42	S	S	S	S	S		M	VS	M	D	D
V	33	S	S	S	S	S		M	VS	M	D	D
	34	S	S	S	S	S		M	VS	M	D	D
	35	S	S	S	S	S		M	VS	M	D	D
	36	S	S	S	S	S		M	VS	M	D	D
	37	S	S	S	S	S		M	VS	M	D	D
	38	S	S	S	S	S		M	VS	M	D	D
	39	S	S	S	S	S		M	VS	M	D	D
	40	S	S	S	S	S		M	VS	M	D	D
	41	S	S	S	S	S		M	VS	M	D	D
	42	S	S	S	S	S		M	VS	M	D	D
X	33	VC	VC	C	VC	VC		VC	C	VC	L	M
	34	VC	VC	C	VC	VC		VC	C	VC	L	M
	35	VC	VC	C	VC	VC		VC	C	VC	L	M
	36	VC	VC	C	VC	VC		VC	C	VC	L	M
	37	VC	VC	C	VC	VC		VC	C	VC	L	M
	38	VC	VC	C	VC	VC		VC	C	VC	L	M
	39	VC	VC	C	VC	VC		VC	C	VC	L	M
	40	VC	VC	C	VC	VC		VC	C	VC	L	M
	41	VC	VC	C	VC	VC		VC	C	VC	L	M
	42	VC	VC	C	VC	VC		VC	C	VC	L	M
Z	314	VS	VS	VS	S	VS		S	VS	S	D	D
	422	VC	VC	C	VC	C		VC	C	C	L	M
	423	VC	VC	C	VC	C		VC	C	C	L	M
	424	VC	VC	C	VC	C		VC	C	C	L	M
	509	VS	VS	S	VS	S		C	VS	M	D	D
	513	VS	VS	S	VS	S		C	VS	M	D	D
	516	VS	VS	S	VS	S		C	VS	M	D	D
	607	VS	VS	S	VS	S		C	VS	M	D	D
	608	VS	VS	S	VS	S		C	VS	M	D	D
	609	VS	VS	S	VS	S		C	VS	M	D	D
	712	VS	VS	S	VS	S		C	VS	M	D	D
	714	VS	VS	S	VS	S		C	VS	M	D	D
	715	VS	VS	S	VS	S		C	VS	M	D	D
O	29	VC	VC	VC	VC	VC		VC	C	VC	L	L
	30	VC	VC	VC	VC	VC		VC	C	VC	L	L
	31	VC	VC	VC	VC	VC		VC	C	VC	L	L
	32	VC	VC	VC	VC	VC		VC	C	VC	L	L
	33	VC	VC	VC	VC	VC		VC	C	VC	L	L
	34	VC	VC	VC	VC	VC		VC	C	VC	L	L
	35	VC	VC	VC	VC	VC		VC	C	VC	L	L
	36	VC	VC	VC	VC	VC		VC	C	VC	L	L
Y♦	7	M	M	M	C	C		C	M	C	M	M
	8	M	M	M	C	C		C	M	C	M	M
	9	M	M	M	C	C		C	M	C	M	M
YY♦	7	C	C	C	C	C		C	C	C	M	M
	8	C	C	C	C	C		C	C	C	M	M
	9	C	C	C	C	C		C	C	C	M	M

♦ [illegible]
† [illegible]

§ Exposed 6-8-17.

n gone to Extent of 15%.
x6".
ilure.
Bottom.
ilure.
dental.

Sheets D 36 2" Hole.
" D 38 3" " .
" E 32 4" " .
" E 36 2" " .
" I 50 2" " Accidental.
" S 33 1" " .
" S 34 12" " .
" S 35 10" " .
" S 36 5" " .
" S 37 to 40 incl. 6" " .
" S 41 8" " .
" S 42 4" " .
" V 40 2" " Accidental.

Sheets X 33 2" Hole.
" X 34 Lower 10 inches Gone.
" X* 35 1" Hole.
" X 36 1" " .
" X 37 8" " .
" X 38 Lower 10 inches Gone.
" X 39 2" Hole.
" X 40 4" " .
" X 41 & 42 2" " .
" Z 422, 423 & 424 Failure.
" O 29 to 36 incl. Complete Failure.

— BUCK —

Sheets AA 21 to 24 incl. Rusting Rapidly.
" DD 25 to 28 " " " .
" SS 29 to 32 " " " .
" XX 29 to 32 " " " .
" ZZ 8, 10 & 14 " " .
" A 31 to 34 " Failure.
" D 30 " .
" S 29 to 32 " " .
" X 29 to 32 " " .
" O 25 to 28 " " .
" Z 6, 7 & 11 " .
" AA 25 to 30 " Rusting Rapidly.
" AA 50 to 56 " " " .

Sheets DD 8 to 10 incl. Rusting Rapidly.
" DD 29 to 31 " " " .
" DD 47 to 49 " " " .
" DD 54 to 58 " " " .
" SS 33 to 42 " " " .
" XX 33 to 42 " " " .
" A 36 to 47 " Failure.
" B 37 " .
" B 28 Damaged.
" D 36 & 38 Failure.
" E 32 & 36 " .
" S 33 to 42 " " .
" X 33 to 42 " " .

PLATE I.
PROC. AM. SOC. TEST. MATS.
VOL. XIX, PART I.

REPORT OF COMMITTEE A-5:
CORROSION TESTS.

Weather *Fair, Cool, Overcast.*

	CONDITION OF RUST																	
	Color									Adherence								
Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
VC	L	M	M	L	L		L	M	M	L	L	L	L	L		L	L	L
VC	L	M	M	L	L		L	M	M	L	L	L	L	L		L	L	L
VC	L	M	M	L	L		L	M	M	L	L	L	L	L		L	L	L
VC	L	M	M	L	L		L	M	M	L	L	L	L	L		L	L	L
VC	L	M	M	L	L		L	M	M	L	L	L	L	L		L	L	L
VC	L	M	M	L	L		L	M	M	L	L	L	L	L		L	L	L
VC	L	M	M	L	L		L	M	M	L	L	L	L	L		L	L	L
VC	L	M	M	L	L		L	M	M	L	L	L	L	L		L	L	L
VC	L	M	M	L	L		L	M	M	L	L	L	L	L		L	L	L
VC	L	M	M	L	L		L	M	M	L	L	L	L	L		L	L	L
S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
C	L	M	M	L	L		L	M	M	L	L	L	L	L		L	L	T
C	L	M	M	L	L		L	M	M	L	L	L	L	L		L	L	T
C	L	M	M	L	L		L	M	M	L	L	L	L	L		L	L	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
VC	L	L	L	L	L		L	L	L	L	L	L	L	L		L	L	L
VC	L	L	L	L	L		L	L	L	L	L	L	L	L		L	L	L
VC	L	L	L	L	L		L	L	L	L	L	L	L	L		L	L	L
VC	L	L	L	L	L		L	L	L	L	L	L	L	L		L	L	L
VC	L	L	L	L	L		L	L	L	L	L	L	L	L		L	L	L
VC	L	L	L	L	L		L	L	L	L	L	L	L	L		L	L	L
VC	L	L	L	L	L		L	L	L	L	L	L	L	L		L	L	L
VC	L	L	L	L	L		L	L	L	L	L	L	L	L		L	L	L
C	M	M	M	L	M		M	M	M	T	L	T	L	T		T	L	T
C	M	M	M	L	M		M	M	M	T	L	T	L	T		T	L	T
C	M	M	M	L	M		M	M	M	T	L	T	L	T		T	L	T
C	M	M	L	L	M		L	L	M	T	L	TL	L	T		L	L	T
C	M	M	L	L	M		L	L	M	T	L	TL	L	T		L	L	T
C	M	M	L	L	M		L	L	M	T	L	TL	L	T		L	L	T

— FLEMING —

Sheets A 31 to 34 incl. Failed.
" D 30 "
" S 29 to 32 " . "
" X 29 to 32 " . "
" O 25 to 28 " . "
" Z 6, 7 & 11 "
" A 35 to 47 " . "
" B 37 " (1-Hole)
" B 38 Damaged.
" D 36 & 38 Failed (1-Hole)
" E 32 & 36 " (1-Hole)
" I 50 One Hole Accidental.
" S 33 to 42 " . Failed.
" T 34 & 35 Upper Right Corner Bent.
" V 40 One Hole Accidental.
" X 33 to 42 " . Failed.
" Z 422, 423 & 424 " .
" O 29 to 36 incl. " .

All Sheets which Failed with One Hole only are so Designated. All Others are Rank Failures.

— GIBBONEY —

Sheets A 31 to 34 incl. Failure.
" D 30 " .
" S 29 to 32 " . " .
" X 29 to 32 " . " .
" O 25 to 28 " . " .
" Z 6, 7 & 11 " .
" A 35 to 47 " . " .
" B 37 " .
" B 38 Damaged.
" D 36 & 38 Failure.
" E 32 & 36 " .
" I 50 One Hole Accidental.
" S 33 to 42 " . Failure.
" T 34 & 35 Upper Right Corner Bent.
" V 40 One Hole Accidental.
" X 33 to 42 " . Failure.
" Z 422, 423 & 424 " .
" O 29 to 36 incl. " .

— MC ADAM —

Did not make Inspection.

— MC DONNELL —

Sheets A 31 to 34 incl. Failed, Lower End of Sheet.
" D 30 " " " " " .
" S 29 to 32 " . " " " " " .
" X 29 to 32 " . " " " " " .
" O 25 to 28 " . " " " " " . ← Approx. $\frac{1}{2}$ of each Sheet Completely Gone.
" Z 6, 7 & 11 " " " " " .
" OO 29 to 36 " . Color Light to Medium.
" A 35 to 43 " . Failed, Lower End of Sheet.
" A 45 & 47 " " " " " .
" A 44 & 46 " " " " " , also Hole.
" B 37 Failed, Hole.
" B 38 Damaged.
" D 36 & 38 Failed, Hole.
" E 32 & 36 " " .
" I 50 Hole Accidental.
" S 33 Failed, One Small Hole.
" S 34 & 35 " , Lower End of Sheet.
" S 36 " , One Hole.
" S 37 to 40 incl. " , Several Holes.
" S 41 " , Lower End of Sheet.
" S 42 " , Two Holes.
" V 40 Hole Accidental.
" X 33, 34 & 38 Failed, Lower End of Sheet.
" X 35, 36, 40 & 41 " , One Hole.
" X 37 " , Lower End of Sheet, also Right Side.
" X 39 & 42 " , " " " " , " One Hole.
" Z 422 & 423 " , Three Holes.
" Z 424 " , Lower End of Sheet.
" O 29 to 36 incl. " , Approximately $\frac{1}{3}$ to $\frac{1}{4}$ Gone.

— SMITH —

Sheets A 31 to 34 incl. Failed at Bottom.
" D 30 Lower Left Corner Failed.
" S 29 to 32 " Failed at Bottom.
" X 29 to 32 " " " " .
" O 25 to 28 " Entirely Gone.
" Z 6, 7 & 11 Failed at Bottom.
" A 35 to 47 " All Failed at Lower End; Lumber Piled Underneath, Possibly Mechanical Injury from Lumber Handling.
" B 37 One $1\frac{1}{4}$" Hole Rusted through near Bottom.
" B 38 Lower Left Corner Injured, Bent down.
" D 36 & 38 Failed on Account of Rust.
" E 36 $\frac{3}{4}$" x $1\frac{1}{4}$" Hole Rusted through.
" I 50 $\frac{7}{8}$" x 2" Accidental Hole.
" S 33 to 42 " All Failed on Account of Rust.
" V 40 $\frac{3}{8}$" Accidental Hole.
" X 33 to 42 " All Failed, – Rusted through at Lower Ends.
" Z 422, 423 & 424 Failed, – Rust.
" O 29 to 36 incl. All Failed, on Account of Rust.
" E 32 Failed, on Account of Rust.

— WHEATON —

Sheets A 31 to 34 incl. Failed.
" D 30 " .
" S 29 to 32 " " .
" X 29 to 32 " " .
" O 25 to 28 " " .
" Z 6, 7 & 11 " .
" A 35 to 47 " " .
" B 37 " .
" B 38 Hole.
" D 36 & 38 Failed.
" E 32 & 36 " .
" I 50 Hole.
" S 33 to 42 " Failed.
" I 34 & 35 Corner Bent.
" V 40 Hole.
" X 33 to 42 " Failed.
" Z 422, 423 & 424 " .
" O 29 to 36 incl. " .

pidly. *Sheets Z 422, 423 & 424 Failure.*
" . " O 29 to 36 incl. " .
" .
" . *Sheets all very Dirty and therefore Dark,*
" . *except those which are Rusting Rapidly, thus*
" . *Scaling off and Exposing Fresh Red Oxide.*

— COOPER —

Sheets A 31 to 34 incl. Failed.
" D 30 " .
" S 29 to 32 " " .
" X 29 to 32 " " .
" O 25 to 28 " " .
" Z 6, 7 & 11 " .
" A 35 to 47 " " .
" D 36 & 38 " .
" E 32 & 36 " .
" S 33 to 42 " " .
" I 50 Hole Punched in it.
" V 40 " " " " .
" X 33 to 42 " Failed.

Sheets Z 422, 423 & 424 Failed.
" O 29 to 36 incl. " .

James H. Gibboney

Date of Inspection *Oct. 8, 1918.*

ROW No. 1

DESIGNATION		CONDITION OF RUST																										
Mark	Sheet No.	Texture									Color									Adherence								
		1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton
AA	1	VC	VC	VC		VC		C	M	VC	L	M	M		L		L	L	D	L	L	L		L		L	L	L
	2	VC	VC	VC		VC		C	M	VC	L	M	M		L		L	L	D	L	L	L		L		L	L	L
	3	VC	VC	VC		VC		C	M	VC	L	M	M		L		L	L	D	L	L	L		L		L	L	L
BB	1	M	M	C		M		M	M	C	M	D	M		M		M	M	D	T	T	TL		L		L	L	L
	2	M	M	C		M		M	M	C	M	D	M		M		M	M	D	T	T	TL		L		L	L	L
	3	M	M	C		M		M	M	C	M	D	M		M		M	M	D	T	T	TL		L		L	L	L
CC	1	M	C	M		M		M	M	VC	L	L	M		L		L	L	M	T	L	T		L		L	L	L
	2	M	C	M		M		M	M	VC	L	L	M		L		L	L	M	T	L	T		L		L	L	L
	3	M	C	M		M		M	M	VC	L	L	M		L		L	L	M	T	L	T		L		L	L	L
DD	1	M	C	M		M		M	M	VC	L	L	M		M		L	L	M	T	L	T		T		L	L	L
	2	M	C	M		M		M	M	VC	L	L	M		M		L	L	M	T	L	T		T		L	L	L
	3	M	C	M		M		M	M	VC	L	L	M		M		L	L	M	T	L	T		T		L	L	L
EE¶	1	M	M	S		M		M	C	C	L	L	M		L		L	L	M	T	T	T		T		L	L	L
	2	M	M	S		M		M	C	C	L	L	M		L		L	L	M	T	T	T		T		L	L	L
	3	M	M	S		M		M	C	C	L	L	M		L		L	L	M	T	T	T		T		L	L	L
HH	1	M	S	S		M		S	M	M	M	D	D		D		M	M	D	T	T	T		T		T	L	T
	2	M	S	S		M		S	M	M	M	D	D		D		M	M	D	T	T	T		T		T	L	T
	3	M	S	S		M		S	M	M	M	D	D		D		M	M	D	T	T	T		T		T	L	T
II	1	M	VS	S		S		S	M	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	2	M	VS	S		S		S	M	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	3	M	VS	S		S		S	M	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
KK	1	S	VS	S		S		S	M	M	M	D	D		D		D	M	D	T	T	T		T		L	L	T
	2	S	VS	S		S		S	M	M	M	D	D		D		D	M	D	T	T	T		T		L	L	T
	3	S	VS	S		S		S	M	M	M	D	D		D		D	M	D	T	T	T		T		L	L	T
MM¶	1	S	M	M		M		M	M	M	M	D	D		D		M	M	D	T	T	T		T		T	L	T
	2	S	M	M		M		M	M	M	M	D	D		D		M	M	D	T	T	T		T		T	L	T
	3	S	M	M		M		M	M	M	M	D	D		D		M	M	D	T	T	T		T		T	L	T
SS	1	C	C	C		C		C	C	C	L	L	L		L		L	L	L	T	L	L		L		L	L	L
	2	C	C	C		C		C	C	C	L	L	L		L		L	L	L	T	L	L		L		L	L	L
	3	C	C	C		C		C	C	C	L	L	L		L		L	L	L	T	L	L		L		L	L	L
TT	1	S	S	S		M		M	C	M	M	M	D		D		D	M	D	T	T	T		T		T	L	T
	2	S	S	S		M		M	C	M	M	M	D		D		D	M	D	T	T	T		T		T	L	T
	3	S	S	S		M		M	C	M	M	M	D		D		D	M	D	T	T	T		T		T	L	T
UU	1	S	M	S		M		M	C	M	M	M	M		M		M	L	M	T	T	T		T		T	L	T
	2	S	M	S		M		M	C	M	M	M	M		M		M	L	M	T	T	T		T		T	L	T
	3	S	M	S		M		M	C	M	M	M	M		M		M	L	M	T	T	T		T		T	L	T
VV	1	S	M	S		M		M	C	M	M	M	M		M		M	L	M	T	T	T		T		T	L	T
	2	S	M	S		M		M	C	M	M	M	M		M		M	L	M	T	T	T		T		T	L	T
	3	S	M	S		M		M	C	M	M	M	M		M		M	L	M	T	T	T		T		T	L	T
XX	1	S	C	C		C		M	C	C	M	L	M		M		M	L	M	T	L	TL		L		T	L	L
	2	S	C	C		C		M	C	C	M	L	M		M		M	L	M	T	L	TL		L		T	L	L
	3	S	C	C		C		M	C	C	M	L	M		M		M	L	M	T	L	TL		L		T	L	L
OO	1	S	M	C		M		M	M	M	M	D	D		D		D	M	D	T	L	TL		T		T	L	L
	2	S	M	C		M		M	M	M	M	D	D		D		D	M	D	T	L	TL		T		T	L	L
	3	S	M	C		M		M	M	M	M	D	D		D		D	M	D	T	L	TL		T		T	L	L
QQ‡	25	S	C	M		M		M	C	C	M	L	M		L		L	L	M	T	L	TL		T		T	L	T
	26	S	C	M		M		M	C	C	M	L	M		L		L	L	M	T	L	TL		T		T	L	T
	27	S	C	M		M		M	C	C	M	L	M		L		L	L	M	T	L	TL		T		T	L	T

ROW No. 2

DESIGNATION		CONDITION OF RUST																										
Mark	Sheet No.	Texture									Color									Adherence								
		1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton
A	1	M	VC	VC		C		M	M	M	M	M	D		M		L	M	D	L	L	L		L		L	L	T
	2	M	VC	VC		C		M	M	M	M	M	D		M		L	M	D	L	L	L		L		L	L	T
	3	M	VC	VC		C		M	M	M	M	M	D		M		L	M	D	L	L	L		L		L	L	T
B	1	M	M	C		M		M	M	M	M	M	D		M		M	M	D	T	T	TL		T		L	L	T
	2	M	M	C		M		M	M	M	M	M	D		M		M	M	D	T	T	TL		T		L	L	T
	3	M	M	C		M		M	M	M	M	M	D		M		M	M	D	T	T	TL		T		L	L	T
C	1	M	C	M		C		M	C	M	M	L	M		L		L	L	M	T	L	TL		L		L	L	T
	2	M	C	M		C		M	C	M	M	L	M		L		L	L	M	T	L	TL		L		L	L	T
	3	M	C	M		C		M	C	M	M	L	M		L		L	L	M	T	L	TL		L		L	L	T
D	1	M	C	M		C		C	C	C	M	L	L		L		L	L	M	T	L	TL		L		L	L	L
	2	M	C	M		C		C	C	C	M	L	L		L		L	L	M	T	L	TL		L		L	L	L
	3	M	C	M		C		C	C	C	M	L	L		L		L	L	M	T	L	TL		L		L	L	L
E	1	S	S	S		S		M	M	S	M	M	M		M		M	L	M	T	T	T		T		T	L	T
	2	S	S	S		S		M	M	S	M	M	M		M		M	L	M	T	T	T		T		T	L	T
	3	S	S	S		S		M	M	S	M	M	M		M		M	L	M	T	T	T		T		T	L	T
H	1	S	S	VS		S		S	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	L
	2	S	S	VS		S		S	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	L
	3	S	S	VS		S		S	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	L
I	1	S	VS	S		S		S	S	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	2	S	VS	S		S		S	S	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	3	S	VS	S		S		S	S	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
K	1	S	VS	S		S		S	M	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	2	S	VS	S		S		S	M	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	3	S	VS	S		S		S	M	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
M	1	M	S	M		M		M	C	M	M	D	D		D		D	M	D	T	L	T		T		T	L	T
	2	M	S	M		M		M	C	M	M	D	D		D		D	M	D	T	L	T		T		T	L	T
	3	M	S	M		M		M	C	M	M	D	D		D		D	M	D	T	L	T		T		T	L	T
S	1	M	C	C		C		C	VC	C	M	L	L		L		L	L	L	T	L	L		L		L	L	L
	2	M	C	C		C		C	VC	C	M	L	L		L		L	L	L	T	L	L		L		L	L	L
	3	M	C	C		C		C	VC	C	M	L	L		L		L	L	L	T	L	L		L		L	L	L
T	1	M	VS	S		S		M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
	2	M	VS	S		S		M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
	3	M	VS	S		S		M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
U	1	M	S	M		S		M	C	M	M	D	M		M		M	M	M	T	T	T		T		T	L	T
	2	M	S	M		S		M	C	M	M	D	M		M		M	M	M	T	T	T		T		T	L	T
	3	M	S	M		S		M	C	M	M	D	M		M		M	M	M	T	T	T		T		T	L	T
V	1	M	S	S		M		M	C	C	M	D	L		M		M	M	M	T	T	T		T		T	L	L
	2	M	S	S		M		M	C	C	M	D	L		M		M	M	M	T	T	T		T		T	L	L
	3	M	S	S		M		M	C	C	M	D	L		M		M	M	M	T	T	T		T		T	L	L
X	1	M	C	M		C		C	C	C	M	M	L		M		M	M	M	T	L	TL		L		L	L	L
	2	M	C	M		C		C	C	C	M	M	L		M		M	M	M	T	L	TL		L		L	L	L
	3	M	C	M		C		C	C	C	M	M	L		M		M	M	M	T	L	TL		L		L	L	L
O	1	M	VC	C		VC		C	C	VC	M	D	M		M		D	D	D	T	L	L		L		L	L	L
	2	M	VC	C		VC		C	C	VC	M	D	M		M		D	D	D	T	L	L		L		L	L	L
	3	M	VC	C		VC		C	C	VC	M	D	M		M		D	D	D	T	L	L		L		L	L	L
Z	1	M	C	M		C		M	C	C	M	M	M		D		M	D	D	T	L	TL		L		L	L	L
	2	M	C	M		C		M	C	C	M	M	M		D		M	D	D	T	L	TL		L		L	L	L
	3	M	C	M		C		M	C	C	M	M	M		D		M	D	D	T	L	TL		L		L	L	L

ROW No. 3

DESIGNATION		CONDITION OF RUST																										
Mark	Sheet No.	Texture									Color									Adherence								
		1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton
AA	4	C	VC	VC		C		C	C	C	L	L	M		M		M	M	D	L	L	L		L		L	L	L
	5	C	VC	VC		C		C	C	C	L	L	M		M		M	M	D	L	L	L		L		L	L	L
	6	C	VC	VC		C		C	C	C	L	L	M		M		M	M	D	L	L	L		L		L	L	L
	7	C	VC	VC		C		C	C	C	L	L	M		M		M	M	D	L	L	L		L		L	L	L
	8	C	VC	VC		C		C	C	C	L	L	M		M		M	M	D	L	L	L		L		L	L	L
	9	C	VC	VC		C		C	C	C	L	L	M		M		M	M	D	L	L	L		L		L	L	L
AA+	31	C	C	VC		C		C	C	C	L	M	M		M		M	M	D	L	L	L		L		L	L	L
	32	C	C	VC		C		C	C	C	L	M	M		M		M	M	D	L	L	L		L		L	L	L
	33	C	C	VC		C		C	C	C	L	M	M		M		M	M	D	L	L	L		L		L	L	L
	34	C	C	VC		C		C	C	C	L	M	M		M		M	M	D	L	L	L		L		L	L	L
	35	C	C	VC		C		C	C	C	L	M	M		M		M	M	D	L	L	L		L		L	L	L
	36	C	C	VC		C		C	C	C	L	M	M		M		M	M	D	L	L	L		L		L	L	L
	37	C	C	VC		C		C	C	C	L	M	M		M		M	M	D	L	L	L		L		L	L	L
	38	C	C	VC		C		C	C	C	L	M	M		M		M	M	D	L	L	L		L		L	L	L
	39	C	C	VC		C		C	C	C	L	M	M		M		M	M	D	L	L	L		L		L	L	L
BB	10	M	S	C		M		M	M	M	M	D	M		D		D	D	D	T	T	TL		T		L	L	T
	11	M	S	C		M		M	M	M	M	D	M		D		D	D	D	T	T	TL		T		L	L	T
	12	M	S	C		M		M	M	M	M	D	M		D		D	D	D	T	T	TL		T		L	L	T
	13	M	S	C		M		M	M	M	M	D	M		D		D	D	D	T	T	TL		T		L	L	T
	14	M	S	C		M		M	M	M	M	D	M		D		D	D	D	T	T	TL		T		L	L	T
	37	M	S	C		M		M	M	C	M	D	M		D		D	D	D	T	T	TL		T		L	L	L
BB+	25	M	S	C		M		M	M	S	M	D	M		D		D	D	D	T	T	TL		T		T	L	T
	26	M	S	C		M		M	M	S	M	D	M		D		D	D	D	T	T	TL		T		T	L	T
	27	M	S	C		M		M	M	S	M	D	M		D		D	D	D	T	T	TL		T		T	L	T
	28	M	S	C		M		M	M	S	M	D	M		D		D	D	D	T	T	TL		T		T	L	T
	42	M	S	C		M		M	M	S	M	D	M		D		D	D	D	T	T	TL		T		T	L	T
	43	M	S	C		M		M	M	S	M	D	M		D		D	D	D	T	T	TL		T		T	L	T
	44	M	S	C		M		M	M	S	M	D	M		D		D	D	D	T	T	TL		T		T	L	T
	45	M	S	C		M		M	M	S	M	D	M		D		D	D	D	T	T	TL		T		T	L	T
CC	5	M	M	M		C		C	C	C	L	L	L		L		L	M	L	T	L	T		L		L	L	L
	6	M	M	M		C		C	C	C	L	L	L		L		L	M	L	T	L	T		L		L	L	L
	8	M	M	M		C		C	C	C	L	L	L		L		L	M	L	T	L	T		L		L	L	L
CC+	20	M	M	M		C		M	C	C	M	L	L		M		L	M	M	T	L	T		L		L	L	L
	21	M	M	M		C		M	C	C	M	L	L		M		L	M	M	T	L	T		L		L	L	L
	22	M	M	M		C		M	C	C	M	L	L		M		L	M	M	T	L	T		L		L	L	L
	23	M	M	M		C		M	C	C	M	L	L		M		L	M	M	T	L	T		L		L	L	L
	24	M	M	M		C		M	C	C	M	L	L		M		L	M	M	T	L	T		L		L	L	L
	25	M	M	M		C		M	C	C	M	L	L		M		L	M	M	T	L	T		L		L	L	L
DD	1	M	C	C		C		C	C	C	M	L	L		M		L	M	M	T	L	TL		T		L	L	L
	11	M	C	C		C		C	C	C	M	L	L		M		L	M	M	T	L	TL		T		L	L	L
	12	M	C	C		C		C	C	C	M	L	L		M		L	M	M	T	L	TL		T		L	L	L
	13	M	C	C		C		C	C	C	M	L	L		M		L	M	M	T	L	TL		T		L	L	L
	14	M	C	C		C		C	C	C	M	L	L		M		L	M	M	T	L	TL		T		L	L	L
	15	M	C	C		C		C	C	C	M	L	L		M		L	M	M	T	L	TL		T		L	L	L
DD+	32	M	C	C		C		M	C	C	M	L	M		M		L	M	M	T	L	TL		T		T	L	L
	33	M	C	C		C		M	C	C	M	L	M		M		L	M	M	T	L	TL		T		T	L	L
	34	M	C	C		C		M	C	C	M	L	M		M		L	M	M	T	L	TL		T		T	L	L
	35	M	C	C		C		M	C	C	M	L	M		M		L	M	M	T	L	TL		T		T	L	L
	36	M	C	C		C		M	C	C	M	L	M		M		L	M	M	T	L	TL		T		T	L	L
	37	M	C	C		C		M	C	C	M	L	M		M		L	M	M	T	L	TL		T		T	L	L
	38	M	C	C		C		M	C	C	M	L	M		M		L	M	M	T	L	TL		T		T	L	L

¶ Open Annealed.

‡ Exposed 11-20-18.

+ Sand Blasted.

CONDITION OF RUST.

Texture	Color	Adherence
VS—Very Smooth	L—Light	T—Tight
S—Smooth	M—Medium	L—Loose
M—Medium	D—Dark	
C—Coarse		
VC—Very Coarse		

— INSPECTION COMMITTEE —

J. H. Gibboney, Chairman — Norfolk & Western Ry. Co.
J. A. Aupperle — American Rolling Mill Co.
D. M. Buck — American Sheet & Tin Plate Co.
W. A. Cooper — Alan Wood Iron & Steel Co.
W. R. Fleming — The Andrews Steel Co.
D. J. McAdam, Jr. - U. S. Navy, Bureau Steam Engineering.
M. E. McDonnell - Pennsylvania Railroad Co.
H. E. Smith — New York Central Railroad Co.
F. B. Wheaton — U. S. Army, Quartermasters Corps.

— AUPPERLE —

Notes : None.

— BUCK —

The Grading was Difficul
for Adherence. An Attempt
to Use only the two Grades
ence, but I feel that more S
Results would have been Obta
Third (Medium) had been U

Table II.—Results of Inspection of Corrosion Test Sheets, at Annapolis, Md., October 8

AMERICAN SOCIETY FOR TESTING MATERIALS

COMMITTEE A-5 ON CORROSION OF IRON AND STEEL
TESTS OF UNCOATED SHEETS
ANNAPOLIS, MARYLAND

EXPOSED OCTOBER 17, 1916

McDonnell	Smith	Wheaton
7	8	9
L	L	L
L	L	L
L	L	L
L	L	L
L	L	L
L	L	L
L	L	L
L	L	L
L	L	L
L	L	L
L	L	L
L	L	L
L	L	L
L	L	L
L	L	L
L	L	T
L	L	T
L	L	T
L	L	T
L	L	T
L	L	L
T	L	T
T	L	T
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L	L	L
L	L	L
L	L	L
L	L	L
L	L	L
L	L	L
L	L	L
L	L	L
L	L	L
T	L	L
T	L	L
T	L	L
T	L	L
T	L	L
T	L	L
T	L	L

ROW No. 4

Designation		Condition of Rust																										
		Texture									Color									Adherence								
Mark	Sheet No.	Aupperle	Buck	Cooper	Fleming	Gibboney	McAdam	McDonnell	Smith	Wheaton	Aupperle	Buck	Cooper	Fleming	Gibboney	McAdam	McDonnell	Smith	Wheaton	Aupperle	Buck	Cooper	Fleming	Gibboney	McAdam	McDonnell	Smith	Wheaton
		1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
DU*	41	M	C	C		M		M	M	M	M	M	M		M		L	L	M	T	L	TL		T		L	L	T
	42	M	C	C		M		M	M	M	M	M	M		M		L	L	M	T	L	TL		T		L	L	T
	43	M	C	C		M		M	M	M	M	M	M		M		L	L	M	T	L	TL		T		L	L	T
EE†	4	M	M	M		M		M	M	M	M	M	M		M		L	L	M	T	L	T		T		L	L	T
	5	M	M	M		M		M	M	M	M	M	M		M		L	L	M	T	L	T		T		L	L	T
	6	M	M	M		M		M	M	M	M	M	M		M		L	L	M	T	L	T		T		L	L	T
EE*†	19	M	S	M		M		M	S	S	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	20	M	S	M		M		M	S	S	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	21	M	S	M		M		M	S	S	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	22	M	S	M		M		M	S	S	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	23	M	S	M		M		M	S	S	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	24	M	S	M		M		M	S	S	M	M	M		M		M	M	M	T	T	T		T		T	L	T
HH	4	S	S	M		M		M	M	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	5	S	S	M		M		M	M	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	6	S	S	M		M		M	M	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	7	S	S	M		M		M	M	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	8	S	S	M		M		M	M	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	9	S	S	M		M		M	M	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
HH*	27	S	S	M		S		S	S	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	28	S	S	M		S		S	S	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	29	S	S	M		S		S	S	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	30	S	S	M		S		S	S	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	31	S	S	M		S		S	S	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	32	S	S	M		S		S	S	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	33	S	S	M		S		S	S	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
II	4	S	VS	S		M		S	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	5	S	VS	S		M		S	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	6	S	VS	S		M		S	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	7	S	VS	S		M		S	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	8	S	VS	S		M		S	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
II*	30	S	VS	S		S		S	S	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	31	S	VS	S		S		S	S	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	32	S	VS	S		S		S	M	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	33	S	VS	S		S		S	M	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	34	S	VS	S		S		S	M	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	35	S	VS	S		S		S	M	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	36	S	VS	S		S		S	M	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	37	S	VS	S		S		S	M	S	M	D	D		D		D	M	D	T	T	T		T		T	L	T
KK	9	S	VS	S		M		M	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	10	S	VS	S		M		M	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	11	S	VS	S		M		M	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	12	S	VS	S		M		M	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	13	S	VS	S		M		M	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	14	S	VS	S		M		M	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	15	S	VS	S		M		M	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
KK*	35	S	VS	S		M		S	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	36	S	VS	S		M		S	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	37	S	VS	S		M		S	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	38	S	VS	S		M		S	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	39	S	VS	S		M		S	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	40	S	VS	S		M		S	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T

* Sand Blasted
† Cross Annealed

ROW No. 5

Designation		Condition of Rust																										
		Texture									Color									Adherence								
Mark	Sheet No.	Aupperle	Buck	Cooper	Fleming	Gibboney	McAdam	McDonnell	Smith	Wheaton	Aupperle	Buck	Cooper	Fleming	Gibboney	McAdam	McDonnell	Smith	Wheaton	Aupperle	Buck	Cooper	Fleming	Gibboney	McAdam	McDonnell	Smith	Wheaton
		1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
KK*	41	VS	S	S		S		S	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	42	VS	S	S		S		S	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
MM†	4	S	M	M		M		M	C	M	M	D	M		D		M	D	D	T	L	T		T		T	L	T
	5	S	M	M		M		M	C	M	M	D	M		D		M	D	D	T	L	T		T		T	L	T
	6	S	M	M		M		M	C	M	M	D	M		D		M	D	D	T	L	T		T		T	L	T
	7	S	M	M		M		M	C	M	M	D	M		D		M	D	D	T	L	T		T		T	L	T
	8	S	M	M		M		M	C	M	M	D	M		D		M	D	D	T	L	T		T		T	L	T
	9	S	M	M		M		M	C	M	M	D	M		D		M	D	D	T	L	T		T		T	L	T
	10	S	M	M		M		M	C	M	M	D	M		D		M	D	D	T	L	T		T		T	L	T
	11	S	M	M		M		M	C	M	M	D	M		D		M	D	D	T	L	T		T		T	L	T
	12	S	M	M		M		M	C	M	M	D	M		D		M	D	D	T	L	T		T		T	L	T
	13	S	M	M		M		M	C	M	M	D	M		D		M	D	D	T	L	T		T		T	L	T
	14	S	M	M		M		M	C	M	M	D	M		D		M	D	D	T	L	T		T		T	L	T
SS	4	M	C	C		C		C	C	VC	M	L	L		L		L	M	M	T	L	TL		L		L	L	L
	5	M	C	C		C		C	C	VC	M	L	L		L		L	M	M	T	L	TL		L		L	L	L
	6	M	C	C		C		C	C	VC	M	L	L		L		L	M	M	T	L	TL		L		L	L	L
	7	M	C	C		C		C	C	VC	M	L	L		L		L	M	M	T	L	TL		L		L	L	L
	8	M	C	C		C		C	C	VC	M	L	L		L		L	M	M	T	L	TL		L		L	L	L
	9	M	C	C		C		C	M	VC	M	L	L		L		L	M	M	T	L	TL		L		L	L	L
	10	M	C	C		C		C	M	VC	M	L	L		L		L	M	M	T	L	TL		L		L	L	L
	11	M	C	C		C		C	M	VC	M	L	L		L		L	M	M	T	L	TL		L		L	L	L
	12	M	C	C		C		C	M	VC	M	L	L		L		L	M	M	T	L	TL		L		L	L	L
	13	M	C	C		C		C	M	VC	M	L	L		L		L	M	M	T	L	TL		L		L	L	L
	14	M	C	C		C		C	M	VC	M	L	L		L		L	M	M	T	L	TL		L		L	L	L
TT	4	S	S	M		S		M	M	S	M	D	D		D		D	D	D	T	T	T		T		T	L	T
	5	S	S	M		S		M	M	S	M	D	D		D		D	D	D	T	T	T		T		T	L	T
	6	S	S	M		S		M	M	S	M	D	D		D		D	D	D	T	T	T		T		T	L	T
	7	S	S	M		S		M	M	S	M	D	D		D		D	D	D	T	T	T		T		T	L	T
	8	S	S	M		S		M	M	S	M	D	D		D		D	D	D	T	T	T		T		T	L	T
	9	S	S	M		S		M	M	S	M	D	D		D		D	D	D	T	T	T		T		T	L	T
	10	S	S	M		S		M	M	S	M	D	D		D		D	D	D	T	T	T		T		T	L	T
	11	S	S	M		S		M	M	S	M	D	D		D		D	D	D	T	T	T		T		T	L	T
	12	S	S	M		S		M	M	S	M	D	D		D		D	D	D	T	T	T		T		T	L	T
	13	S	S	M		S		M	M	S	M	D	D		D		D	D	D	T	T	T		T		T	L	T
	14	S	S	M		S		M	M	S	M	D	D		D		D	D	D	T	T	T		T		T	L	T
UU	4	S	M	M		M		M	C	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	5	S	M	M		M		M	C	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	6	S	M	M		M		M	C	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	7	S	M	M		M		M	C	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	8	S	M	M		M		M	C	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	9	S	M	M		M		M	C	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	10	S	M	M		M		M	C	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	11	S	M	M		M		M	C	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	12	S	M	M		M		M	C	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	13	S	M	M		M		M	C	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	14	S	M	M		M		M	C	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
VV	4	S	M	M		M		M	M	M	M	M	M		M		M	M	M	T	T	T		L		T	L	T
	5	S	M	M		M		M	M	M	M	M	M		M		M	M	M	T	T	T		L		T	L	T
	6	S	M	M		M		M	M	M	M	M	M		M		M	M	M	T	T	T		L		T	L	T

* Sand Blasted
† Cross Annealed

ROW No. 6

Designation		Condition of Rust																										
		Texture									Color									Adherence								
Mark	Sheet No.	Aupperle	Buck	Cooper	Fleming	Gibboney	McAdam	McDonnell	Smith	Wheaton	Aupperle	Buck	Cooper	Fleming	Gibboney	McAdam	McDonnell	Smith	Wheaton	Aupperle	Buck	Cooper	Fleming	Gibboney	McAdam	McDonnell	Smith	Wheaton
		1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
VV	7	M	M	M		M		M	M	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	8	M	M	M		M		M	M	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	9	M	M	M		M		M	M	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	10	M	M	M		M		M	M	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	11	M	M	M		M		M	M	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	12	M	M	M		M		M	M	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	13	M	M	M		M		M	M	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	14	M	M	M		M		M	M	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
XX	4	C	C	C		C		C	M	M	M	L	M		M		M	M	M	L	L	TL		L		L	L	T
	5	C	C	C		C		C	M	M	M	L	M		M		M	M	M	L	L	TL		L		L	L	T
	6	C	C	C		C		C	M	M	M	L	M		M		M	M	M	L	L	TL		L		L	L	T
	7	C	C	C		C		C	M	M	M	L	M		M		M	M	M	L	L	TL		L		L	L	T
	8	C	C	C		C		C	M	M	M	L	M		M		M	M	M	L	L	TL		L		L	L	T
	9	C	C	C		C		C	M	M	M	L	M		M		M	M	M	L	L	TL		L		L	L	T
	10	C	C	C		C		C	M	M	M	L	M		M		M	M	M	L	L	TL		L		L	L	T
	11	C	C	C		C		C	M	M	M	L	M		M		M	M	M	L	L	TL		L		L	L	T
	12	C	C	C		C		C	M	M	M	L	M		M		M	M	M	L	L	TL		L		L	L	T
	13	C	C	C		C		C	M	M	M	L	M		M		M	M	M	L	L	TL		L		L	L	T
	14	C	C	C		C		C	M	M	M	L	M		M		M	M	M	L	L	TL		L		L	L	T
ZZ	1	M	C	C		C		M	C	M	M	L	M		M		M	D	D	L	L	L		L		L	L	T
	2	M	C	C		C		M	C	M	M	L	M		M		M	D	D	L	L	L		L		L	L	T
	4	M	C	C		C		M	C	S	M	L	M		M		M	D	D	L	L	L		L		L	L	T
	307	VS	S	M		S		S	M	S	D	M	D		D		D	D	D	T	T	T		T		T	L	T
	501	VS	S	S		S		S	S	S	D	M	D		D		D	D	D	T	T	T		T		T	L	T
	502	VS	S	S		S		S	S	S	D	M	D		D		D	D	D	T	T	T		T		T	L	T
	503	VS	S	S		S		S	M	S	D	M	D		D		D	D	D	T	T	T		T		T	L	T
	201	VS	S	S		S		S	M	S	D	M	D		D		D	D	D	T	T	T		T		T	L	T
	232	VS	S	S		S		S	M	S	D	M	D		D		D	D	D	T	T	T		T		T	L	T
	204	VS	S	S		S		S	M	S	D	M	D		D		D	D	D	T	T	T		T		T	L	T
	306	VS	S	S		S		S	M	S	D	M	D		D		D	D	D	T	T	T		T		T	L	T
	602	VS	S	S		S		M	M	S	D	M	D		D		D	D	D	T	T	T		T		T	L	T
	605	VS	S	S		S		S	M	S	D	M	D		D		D	D	D	T	T	T		T		T	L	T
	710	VS	S	S		M		M	M	S	D	M	D		D		D	D	D	T	T	T		T		T	L	T
	711	VS	S	S		M		M	M	S	D	M	D		D		D	D	D	T	T	T		T		T	L	T
	102	VS	S	S		S		M	M	S	D	M	D		D		D	D	D	T	T	T		T		T	L	T
	103	VS	S	S		S		M	M	S	D	M	D		D		D	D	D	T	T	T		T		T	L	T
	417	VS	C	S		S		M	C	M	D	M	D		D		M	M	D	T	L	T		T		T	L	T
	418	VS	C	S		S		M	C	M	D	M	D		D		M	M	D	T	L	T		T		T	L	T
	419	VS	C	S		S		M	C	M	D	M	D		D		M	M	D	T	L	T		T		T	L	T
OO	4	S	C	C		C		C	C	C	D	D	M		M		M	D	D	T	L	TL		L		L	L	T
	5	S	C	C		C		C	C	C	D	D	M		M		M	D	D	T	L	TL		L		L	L	T
	6	S	C	C		C		C	C	C	D	D	M		M		M	D	D	T	L	TL		L		L	L	T
	7	S	C	C		C		C	C	C	D	D	M		M		M	D	D	T	L	TL		L		L	L	T
	8	S	C	C		C		C	C	C	D	D	M		M		M	D	D	T	L	TL		L		L	L	T
	9	S	C	C		C		C	C	C	D	D	M		M		M	D	D	T	L	TL		L		L	L	T
	10	S	C	C		C		C	C	C	D	D	M		M		M	D	D	T	L	TL		L		L	L	T
	11	S	C	C		C		C	C	C	D	D	M		M		M	D	D	T	L	TL		L		L	L	T
	12	S	C	C		C		C	C	C	D	D	M		M		M	D	D	T	L	TL		L		L	L	T

ROW No. 7

Designation			
Mark	Sheet No.	Aupperle	Buck
		1	2
[illegible]	28	S	C
	29	S	C
	30	S	C
	31	S	C
	32	S	C
	33	S	C
	34	S	C
	35	S	C
A	4	M	C
	5	M	
	6	M	
	7	M	
	8	M	
	9	M	
	10	M	
	11	M	
	12	M	
	13	M	
	14	M	
	15	M	
B	4	M	
	6	M	
	7	M	
	8	M	
	24	M	
	25	M	
	26	M	
	27	M	
	28	M	
C	4	M	
	5	M	
	15	M	
	16	M	
	17	M	
	23	M	
	24	M	
	25	M	
	26	M	
D	8	M	
	9	M	
	13	M	
	14	M	
E	4	S	
	5	S	
	6	S	
	7	S	
	8	S	
	9	S	
	10	S	
	11	S	

* Exposed 11-28-1

s Difficult, especially
Attempt was Made
Grades for Adher-
t more Satisfactory
been Obtained if a
d been Used.

— COOPER —

Sheets were all in Good Condition and no Failures to Note.

The Sand Blasted Sheets were very Slightly Darker in Color than those not Sand Blasted.

Sheets Marked "TL" indicates Approximate Mean Condition between "Tight" and "Loose."

— FLEMING —

Did not Make this Inspection.

— GIBBONEY —

Notes: None.

— M

Did not

pection of Corrosion Test Sheets, at Annapolis, Md., October 8, 1918.

AMERICAN SOCIETY FOR TESTING MATERIALS

COMMITTEE A-5 ON CORROSION OF IRON AND STEEL
TESTS OF UNCOATED SHEETS
ANNAPOLIS, MARYLAND

EXPOSED OCTOBER 17, 1916

Weather *Fair, Cool,*

Texture Smith 8	Texture Wheaton 9	Color Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Adherence Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9
M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
C	M	M	D	M		D		M	D	D	T	L	T		T		T	L	T
C	M	M	D	M		D		M	D	D	T	L	T		T		T	L	T
C	M	M	D	M		D		M	D	D	T	L	T		T		T	L	T
C	M	M	D	M		D		M	D	D	T	L	T		T		T	L	T
C	M	M	D	M		D		M	D	D	T	L	T		T		T	L	T
C	M	M	D	M		D		M	D	D	T	L	T		T		T	L	T
C	M	M	D	M		D		M	D	D	T	L	T		T		T	L	T
C	M	M	D	M		D		M	D	D	T	L	T		T		T	L	T
C	M	M	D	M		D		M	D	D	T	L	T		T		T	L	T
C	M	M	D	M		D		M	D	D	T	L	T		T		T	L	T
C	M	M	D	M		D		M	D	D	T	L	T		T		T	L	T
C	VC	M	L	L		L		L	M	M	T	L	TL		L		L	L	L
C	VC	M	L	L		L		L	M	M	T	L	TL		L		L	L	L
C	VC	M	L	L		L		L	M	M	T	L	TL		L		L	L	L
C	VC	M	L	L		L		L	M	M	T	L	TL		L		L	L	L
C	VC	M	L	L		L		L	M	M	T	L	TL		L		L	L	L
M	VC	M	L	L		L		L	M	M	T	L	TL		L		L	L	L
M	VC	M	L	L		L		L	M	M	T	L	TL		L		L	L	L
M	VC	M	L	L		L		L	M	M	T	L	TL		L		L	L	L
M	VC	M	L	L		L		L	M	M	T	L	TL		L		L	L	L
M	VC	M	L	L		L		L	M	M	T	L	TL		L		L	L	L
M	VC	M	L	L		L		L	M	M	T	L	TL		L		L	L	L
M	S	M	D	D		D		D	D	D	T	T	T		T		T	L	T
M	S	M	D	D		D		D	D	D	T	T	T		T		T	L	T
M	S	M	D	D		D		D	D	D	T	T	T		T		T	L	T
M	S	M	D	D		D		D	D	D	T	T	T		T		T	L	T
M	S	M	D	D		D		D	D	D	T	T	T		T		T	L	T
M	S	M	D	D		D		D	D	D	T	T	T		T		T	L	T
M	S	M	D	D		D		D	D	D	T	T	T		T		T	L	T
M	S	M	D	D		D		D	D	D	T	T	T		T		T	L	T
M	S	M	D	D		D		D	D	D	T	T	T		T		T	L	T
M	S	M	D	D		D		D	D	D	T	T	T		T		T	L	T
M	S	M	D	D		D		D	D	D	T	T	T		T		T	L	T
C	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
C	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
C	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
C	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
C	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
C	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
C	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
C	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
C	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
C	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
C	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
M	M	M	M	M		M		M	M	M	T	T	T		L		T	L	T
M	M	M	M	M		M		M	M	M	T	T	T		L		T	L	T
M	M	M	M	M		M		M	M	M	T	T	T		L		T	L	T

ROW No. 6

DESIGNATION Mark	Sheet No.	Texture Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Color Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Adherence Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9
VV	7	M	M	M		M		M	M	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	8	M	M	M		M		M	M	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	9	M	M	M		M		M	M	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	10	M	M	M		M		M	M	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	11	M	M	M		M		M	M	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	12	M	M	M		M		M	M	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	13	M	M	M		M		M	M	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
	14	M	M	M		M		M	M	M	M	M	M		M		M	M	M	T	T	T		T		T	L	T
XX	4	C	C	C		C		C	M	M	M	L	M		M		M	M	M	L	L	TL		L		L	L	T
	5	C	C	C		C		C	M	M	M	L	M		M		M	M	M	L	L	TL		L		L	L	T
	6	C	C	C		C		C	M	M	M	L	M		M		M	M	M	L	L	TL		L		L	L	T
	7	C	C	C		C		C	M	M	M	L	M		M		M	M	M	L	L	TL		L		L	L	T
	8	C	C	C		C		C	M	M	M	L	M		M		M	M	M	L	L	TL		L		L	L	T
	9	C	C	C		C		C	M	M	M	L	M		M		M	M	M	L	L	TL		L		L	L	T
	10	C	C	C		C		C	M	M	M	L	M		M		M	M	M	L	L	TL		L		L	L	T
	11	C	C	C		C		C	M	M	M	L	M		M		M	M	M	L	L	TL		L		L	L	T
	12	C	C	C		C		C	M	M	M	L	M		M		M	M	M	L	L	TL		L		L	L	T
	13	C	C	C		C		C	M	M	M	L	M		M		M	M	M	L	L	TL		L		L	L	T
	14	C	C	C		C		C	M	M	M	L	M		M		M	M	M	L	L	TL		L		L	L	T
ZZ	1	M	C	C		C		M	C	M	M	L	M		M		M	D	D	L	L	L		L		L	L	T
	2	M	C	C		C		M	C	M	M	L	M		M		M	D	D	L	L	L		L		L	L	T
	4	M	C	C		C		M	C	S	M	L	M		M		M	D	D	L	L	L		L		L	L	T
	307	VS	S	M		S		S	M	S	D	M	D		D		D	D	D	T	T	T		T		T	L	T
	501	VS	S	S		S		S	S	S	D	M	D		D		D	D	D	T	T	T		T		T	L	T
	502	VS	S	S		S		S	S	S	D	M	D		D		D	D	D	T	T	T		T		T	L	T
	503	VS	S	S		S		S	M	S	D	M	D		D		D	D	D	T	T	T		T		T	L	T
	201	VS	S	S		S		S	M	S	D	M	D		D		D	D	D	T	T	T		T		T	L	T
	202	VS	S	S		S		S	M	S	D	M	D		D		D	D	D	T	T	T		T		T	L	T
	204	VS	S	S		S		S	M	S	D	M	D		D		D	D	D	T	T	T		T		T	L	T
	306	VS	S	S		S		S	M	S	D	M	D		D		D	D	D	T	T	T		T		T	L	T
	602	VS	S	S		S		M	M	S	D	M	D		D		D	D	D	T	T	T		T		T	L	T
	605	VS	S	S		S		S	M	S	D	M	D		D		D	D	D	T	T	T		T		T	L	T
	710	VS	S	S		M		M	M	S	D	M	D		D		D	D	D	T	T	T		T		T	L	T
	711	VS	S	S		M		M	M	S	D	M	D		D		D	D	D	T	T	T		T		T	L	T
	102	VS	S	S		S		M	M	S	D	M	D		D		D	D	D	T	T	T		T		T	L	T
	103	VS	S	S		S		M	M	S	D	M	D		D		D	D	D	T	T	T		T		T	L	T
	417	VS	C	S		S		M	C	M	D	M	D		D		M	M	D	T	L	T		T		T	L	T
	418	VS	C	S		S		M	C	M	D	M	D		D		M	M	D	T	L	T		T		T	L	T
	419	VS	C	S		S		M	C	M	D	M	D		D		M	M	D	T	L	T		T		T	L	T
OO	4	S	C	C		C		C	C	C	D	D	M		M		M	D	D	T	L	TL		L		L	L	T
	5	S	C	C		C		C	C	C	D	D	M		M		M	D	D	T	L	TL		L		L	L	T
	6	S	C	C		C		C	C	C	D	D	M		M		M	D	D	T	L	TL		L		L	L	T
	7	S	C	C		C		C	C	C	D	D	M		M		M	D	D	T	L	TL		L		L	L	T
	8	S	C	C		C		C	C	C	D	D	M		M		M	D	D	T	L	TL		L		L	L	T
	9	S	C	C		C		C	C	C	D	D	M		M		M	D	D	T	L	TL		L		L	L	T
	10	S	C	C		C		C	C	C	D	D	M		M		M	D	D	T	L	TL		L		L	L	T
	11	S	C	C		C		C	C	C	D	D	M		M		M	D	D	T	L	TL		L		L	L	T
	12	S	C	C		C		C	C	C	D	D	M		M		M	D	D	T	L	TL		L		L	L	T

ROW No. 7

DESIGNATION Mark	Sheet No.	Texture Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Color Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Adherence Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9
[illegible]	28	S	C	M		M		C	C	M	M	L	M		M		L	M	M	T	L	TL		L		L	L	T
	29	S	C	M		M		C	C	M	M	L	M		M		L	M	M	T	L	TL		L		L	L	T
	30	S	C	M		M		C	C	M	M	L	M		M		L	M	M	T	L	TL		L		L	L	T
	31	S	C	M		M		C	C	M	M	L	M		M		L	M	M	T	L	TL		L		L	L	T
	32	S	C	M		M		C	C	M	M	L	M		M		L	M	M	T	L	TL		L		L	L	T
	33	S	C	M		M		C	C	M	M	L	M		M		L	M	M	T	L	TL		L		L	L	T
	34	S	C	M		M		C	C	M	M	L	M		M		L	M	M	T	L	TL		L		L	L	T
	35	S	C	M		M		C	C	M	M	L	M		M		L	M	M	T	L	TL		L		L	L	T
A	4	M	C	C		C		C	C	M	M	M	D		M		M	D	D	T	L	TL		L		L	L	T
	5	M	C	C		C		C	C	M	M	M	D		M		M	D	D	T	L	TL		L		L	L	T
	6	M	C	C		C		C	C	M	M	M	D		M		M	D	D	T	L	TL		L		L	L	T
	7	M	C	C		C		C	C	M	M	M	D		M		M	D	D	T	L	TL		L		L	L	T
	8	M	C	C		C		C	C	M	M	M	D		M		M	D	D	T	L	TL		L		L	L	T
	9	M	C	C		C		C	C	M	M	M	D		M		M	D	D	T	L	TL		L		L	L	T
	10	M	C	C		C		C	C	M	M	M	D		M		M	D	D	T	L	TL		L		L	L	T
	11	M	C	C		C		C	C	M	M	M	D		M		M	D	D	T	L	TL		L		L	L	T
	12	M	C	C		C		C	C	M	M	M	D		M		M	D	D	T	L	TL		L		L	L	T
	13	M	C	C		C		C	C	M	M	M	D		M		M	D	D	T	L	TL		L		L	L	T
	14	M	C	C		C		C	C	M	M	M	D		M		M	D	D	T	L	TL		L		L	L	T
	15	M	C	C		C		C	C	M	M	M	D		M		M	D	D	T	L	TL		L		L	L	T
B	4	M	M	M		M		M	C	M	M	M	D		D		M	D	D	T	T	TL		T		T	L	T
	6	M	M	M		M		M	C	M	M	M	D		D		M	D	D	T	T	TL		T		T	L	T
	7	M	M	M		M		M	C	M	M	M	D		D		M	D	D	T	T	TL		T		T	L	T
	8	M	M	M		M		M	C	M	M	M	D		D		M	D	D	T	T	TL		T		T	L	T
	24	M	M	M		M		M	C	M	M	M	D		D		M	D	D	T	T	TL		T		T	L	T
	25	M	M	M		M		M	C	M	M	M	D		D		M	D	D	T	T	TL		T		T	L	T
	26	M	M	M		M		M	C	M	M	M	D		D		M	D	D	T	T	TL		T		T	L	T
	27	M	M	M		M		M	C	M	M	M	D		D		M	D	D	T	T	TL		T		T	L	T
	28	M	M	M		M		M	C	M	M	M	D		D		M	D	D	T	T	TL		T		T	L	T
C	4	M	C	M		C		M	C	M	M	L	M		M		M	M	D	T	L	TL		T		T	L	T
	5	M	C	M		C		M	C	M	M	L	M		M		M	M	D	T	L	TL		T		T	L	T
	15	M	C	M		C		M	C	M	M	L	M		M		M	M	D	T	L	TL		T		T	L	T
	16	M	C	M		C		M	C	M	M	L	M		M		M	M	D	T	L	TL		T		T	L	T
	17	M	C	M		C		M	C	M	M	L	M		M		M	M	D	T	L	TL		T		T	L	T
	23	M	C	M		C		M	C	M	M	L	M		M		M	M	D	T	L	TL		T		T	L	T
	24	M	C	M		C		M	C	M	M	L	M		M		M	M	D	T	L	TL		T		T	L	T
	25	M	C	M		C		M	C	M	M	L	M		M		M	M	D	T	L	TL		T		T	L	T
	26	M	C	M		C		M	C	M	M	L	M		M		M	M	D	T	L	TL		T		T	L	T
D	8	M	C	M		C		C	C	M	M	L	L		L		M	M	M	T	L	TL		L		L	L	T
	9	M	C	M		C		C	C	M	M	L	L		L		M	M	M	T	L	TL		L		L	L	T
	12	M	C	M		C		C	C	M	M	L	L		L		M	M	M	T	L	TL		L		L	L	T
	14	M	C	M		C		C	C	M	M	L	L		L		M	M	M	T	L	TL		L		L	L	T
E	4	S	M	S		M		C	M	M	M	M	M		M		D	M	M	T	T	T		T		L	L	T
	5	S	M	S		M		C	M	M	M	M	M		M		D	M	M	T	T	T		T		L	L	T
	6	S	M	S		M		C	M	M	M	M	M		M		D	M	M	T	T	T		T		L	L	T
	7	S	M	S		M		C	M	M	M	M	M		M		D	M	M	T	T	T		T		L	L	T
	8	S	M	S		M		C	M	M	M	M	M		M		D	M	M	T	T	T		T		L	L	T
	9	S	M	S		M		C	M	M	M	M	M		M		D	M	M	T	T	T		T		L	L	T
	10	S	M	S		M		C	M	M	M	M	M		M		D	M	M	T	T	T		T		L	L	T
	11	S	M	S		M		C	M	M	M	M	M		M		D	M	M	T	T	T		T		L	L	T

ROW No. 8

DESIGNATION Mark	Sheet No.	Texture Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9
H	4	S	S	S		M		M	M	M
	5	S	S	S		M		M	M	M
	6	S	S	S		M		M	M	M
	7	S	S	S		M		M	M	M
	8	S	S	S		M		M	M	M
	9	S	S	S		M		M	M	M
	10	S	S	S		M		M	M	M
	11	S	S	S		M		M	M	M
	12	S	S	S		M		M	M	M
	13	S	S	S		M		M	M	M
	14	S	S	S		M		M	M	M
	16	S	S	S		M		M	M	M
	18	S	S	S		M		M	M	M
I	4	S	VS	S		S		M	M	M
	5	S	VS	S		S		M	M	M
	6	S	VS	S		S		M	M	M
	7	S	VS	S		S		M	M	M
	8	S	VS	S		S		M	M	M
	9	S	VS	S		S		M	M	M
	10	S	VS	S		S		M	M	M
	11	S	VS	S		S		M	M	M
	12	S	VS	S		S		M	M	M
	13	S	VS	S		S		M	M	M
	14	S	VS	S		S		M	M	M
	15	S	VS	S		S		M	M	M
	16	S	VS	S		S		M	M	M
K	4	S	VS	S		M		M	M	M
	5	S	VS	S		M		M	M	M
	6	S	VS	S		M		M	M	M
	7	S	VS	S		M		M	M	M
	8	S	VS	S		M		M	M	M
	9	S	VS	S		M		M	M	M
	10	S	VS	S		M		M	M	M
	11	S	VS	S		M		M	M	M
	12	S	VS	S		M		M	M	M
	13	S	VS	S		M		M	M	M
	14	S	VS	S		M		M	M	M
	15	S	VS	S		M		M	M	M
	16	S	VS	S		M		M	M	M
M	4	M	M	M		M		M	C	C
	5	M	M	M		M		M	C	C
	6	M	M	M		M		M	C	C
	7	M	M	M		M		M	C	C
	8	M	M	M		M		M	C	C
	9	M	M	M		M		M	C	C
	10	M	M	M		M		M	C	C
	11	M	M	M		M		M	C	C
	12	M	M	M		M		M	C	C
	13	M	M	M		M		M	C	C
	14	M	M	M		M		M	C	C

— FLEMING —

Did not Make this Inspection.

— GIBBONEY —

Notes: None.

— McADAM —

Did not Make this Inspection.

— McDONNELL —

Sheets KK 1 to 3 incl. Adherence Approachin
" AA 4 " 9 " Color Medium to Ligh
" BB 25 " 28 " Adherence Approachin
" BB 42 " 45 " " "
" DD 32 " 38 " " "
" EE 4 " 6 " " "
" B 4 " 8 " " "
" B 24 " 28 " " "
" C 4, 5, 15, 16, 17 " "
" C 23 to 26 incl. " "
" I 4 to 16 " Texture "
" K 4 " 16 " " "

PLATE II.
PROC. AM. SOC. TEST. MATS.
VOL. XIX, PART I.

REPORT OF COMMITTEE A-5: CORROSION TESTS.

Cool, Clear.

				CONDITION OF RUST																	
				Color									Adherence								
McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9
	M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	D	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	M	M	M	D	D		D		D	M	D	T	T	T		T		T	L	T
	M	C	C	M	D	D		M		M	M	M	T	T	T		T		T	L	T
	M	C	C	M	D	D		M		M	M	M	T	T	T		T		T	L	T
	M	C	C	M	D	D		M		M	M	M	T	T	T		T		T	L	T
	M	C	C	M	D	D		M		M	M	D	T	T	T		T		T	L	T
	M	C	C	M	D	D		M		M	M	M	T	T	T		T		T	L	T
	M	C	C	M	D	D		M		M	M	D	T	T	T		T		T	L	T
	M	C	C	M	D	D		M		M	M	M	T	T	T		T		T	L	T
	M	C	C	M	D	D		M		M	M	M	T	T	T		T		T	L	T
	M	C	C	M	D	D		M		M	M	M	T	T	T		T		T	L	T
	M	C	C	M	D	D		M		M	M	M	T	T	T		T		T	L	T
	M	C	C	M	D	D		M		M	M	M	T	T	T		T		T	L	T

ROW No. 9

DESIGNATION		CONDITION OF RUST																										
		Texture									Color									Adherence								
Mark	Sheet No.	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9
S	4	M	C	C		C		C	C	C	M	L	L		L		L	M	M	T	L	L		L		L	L	L
	5	M	C	C		C		C	C	C	M	L	L		L		L	M	M	T	L	L		L		L	L	L
	6	M	C	C		C		C	C	C	M	L	L		L		L	M	M	T	L	L		L		L	L	L
	7	M	C	C		C		C	C	C	M	L	L		L		L	M	M	T	L	L		L		L	L	L
	8	M	C	C		C		C	C	C	M	L	L		L		L	M	M	T	L	L		L		L	L	L
	9	M	C	C		C		C	C	C	M	L	L		L		L	M	M	T	L	L		L		L	L	L
	10	M	C	C		C		C	C	C	M	L	L		L		L	M	M	T	L	L		L		L	L	L
	11	M	C	C		C		C	C	C	M	L	L		L		L	M	M	T	L	L		L		L	L	L
	12	M	C	C		C		C	C	C	M	L	L		L		L	M	M	T	L	L		L		L	L	L
	13	M	C	C		C		C	C	C	M	L	L		L		L	M	M	T	L	L		L		L	L	L
	14	M	C	C		C		C	C	C	M	L	L		L		L	M	M	T	L	L		L		L	L	L
T	4	S	S	S		S		M	M	S	D	D	D		D		D	D	D	T	T	T		T		T	L	T
	5	S	S	S		S		M	M	S	D	D	D		D		D	D	D	T	T	T		T		T	L	T
	6	S	S	S		S		M	M	S	D	D	D		D		D	D	D	T	T	T		T		T	L	T
	7	S	S	S		S		M	M	S	D	D	D		D		D	D	D	T	T	T		T		T	L	T
	8	S	S	S		S		M	M	S	D	D	D		D		D	D	D	T	T	T		T		T	L	T
	9	S	S	S		S		M	M	S	D	D	D		D		D	D	D	T	T	T		T		T	L	T
	10	S	S	S		S		M	M	S	D	D	D		D		D	D	D	T	T	T		T		T	L	T
	11	S	S	S		S		M	M	S	D	D	D		D		D	D	D	T	T	T		T		T	L	T
	12	S	S	S		S		M	M	S	D	D	D		D		D	D	D	T	T	T		T		T	L	T
	13	S	S	S		S		M	M	S	D	D	D		D		D	D	D	T	T	T		T		T	L	T
	14	S	S	S		S		M	M	S	D	D	D		D		D	D	D	T	T	T		T		T	L	T
U	4	M	M	M		M		M	C	M	M	M	M		M		M	D	M	T	L	T		T		T	L	L
	5	M	M	M		M		M	C	M	M	M	M		M		M	D	M	T	L	T		T		T	L	L
	6	M	M	M		M		M	C	M	M	M	M		M		M	D	M	T	L	T		T		T	L	L
	7	M	M	M		M		M	C	M	M	M	M		M		M	D	M	T	L	T		T		T	L	L
	8	M	M	M		M		M	C	M	M	M	M		M		M	D	M	T	L	T		T		T	L	L
	9	M	M	M		M		M	C	M	M	M	M		M		M	D	M	T	L	T		T		T	L	L
	10	M	M	M		M		M	C	M	M	M	M		M		M	D	M	T	L	T		T		T	L	L
	11	M	M	M		M		M	C	M	M	M	M		M		M	D	M	T	L	T		T		T	L	L
	12	M	M	M		M		M	C	M	M	M	M		M		M	D	M	T	L	T		T		T	L	L
	13	M	M	M		M		M	C	M	M	M	M		M		M	D	M	T	L	T		T		T	L	L
	14	M	M	M		M		M	C	M	M	M	M		M		M	D	M	T	L	T		T		T	L	L
V	4	M	M	S		M		M	C	M	M	M	M		M		M	M	M	T	L	T		T		T	L	L
	5	M	M	S		M		M	C	M	M	M	M		M		M	M	M	T	L	T		T		T	L	L
	6	M	M	S		M		M	C	M	M	M	M		M		M	M	M	T	L	T		T		T	L	L
	7	M	M	S		M		M	C	M	M	M	M		M		M	M	M	T	L	T		T		T	L	L
	8	M	M	S		M		M	C	M	M	M	M		M		M	M	M	T	L	T		T		T	L	L
	9	M	M	S		M		M	C	M	M	M	M		M		M	M	M	T	L	T		T		T	L	L
	10	M	M	S		M		M	C	M	M	M	M		M		M	M	M	T	L	T		T		T	L	L
	11	M	M	S		M		M	C	M	M	M	M		M		M	M	M	T	L	T		T		T	L	L
	12	M	M	S		M		M	C	M	M	M	M		M		M	M	M	T	L	T		T		T	L	L
	13	M	M	S		M		M	C	M	M	M	M		M		M	M	M	T	L	T		T		T	L	L
	14	M	M	S		M		M	C	M	M	M	M		M		M	M	M	T	L	T		T		T	L	L
V*	1	C	C	C		C		C	C	VC	L	L	L		L		L	L	L	L	L	L		L		L	L	L
	2	C	C	C		C		C	C	VC	L	L	L		L		L	L	L	L	L	L		L		L	L	L
	3	C	C	C		C		C	C	VC	L	L	L		L		L	L	L	L	L	L		L		L	L	L

* Exposed 6-1-1

ROW No. 10

DESIGNATION		CONDITION OF RUST																										
		Texture									Color									Adherence								
Mark	Sheet No.	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9
X	4	M	C	M		C		C	C	VC	M	M	L		L		L	M	L	T	L	TL		L		L	L	L
	5	M	C	M		C		C	C	VC	M	M	L		L		L	M	L	T	L	TL		L		L	L	L
	6	M	C	M		C		C	C	VC	M	M	L		L		L	M	L	T	L	TL		L		L	L	L
	7	M	C	M		C		C	C	VC	M	M	L		L		L	M	L	T	L	TL		L		L	L	L
	8	M	C	M		C		C	C	VC	M	M	L		L		L	M	L	T	L	TL		L		L	L	L
	9	M	C	M		C		C	C	VC	M	M	L		L		L	M	L	T	L	TL		L		L	L	L
	10	M	C	M		C		C	C	VC	M	M	L		L		L	M	L	T	L	TL		L		L	L	L
	11	M	C	M		C		C	C	VC	M	M	L		L		L	M	L	T	L	TL		L		L	L	L
	12	M	C	M		C		C	C	VC	M	M	L		L		L	M	L	T	L	TL		L		L	L	L
	13	M	C	M		C		C	C	VC	M	M	L		L		L	M	L	T	L	TL		L		L	L	L
	14	M	C	M		C		C	C	VC	M	M	L		L		L	M	L	T	L	TL		L		L	L	L
O	4	C	VC	C		VC		C	VC	C	M	D	M		M		M	D	M	L	L	L		L		L	L	L
	5	C	VC	C		VC		C	VC	C	M	D	M		M		M	D	M	L	L	L		L		L	L	L
	6	C	VC	C		VC		C	VC	C	M	D	M		M		M	D	M	L	L	L		L		L	L	L
	7	C	VC	C		VC		C	VC	C	M	D	M		M		M	D	M	L	L	L		L		L	L	L
	8	C	VC	C		VC		C	VC	C	M	D	M		M		M	D	M	L	L	L		L		L	L	L
	9	C	VC	C		VC		C	VC	C	M	D	M		M		M	D	M	L	L	L		L		L	L	L
	10	C	VC	C		VC		C	VC	C	M	D	M		M		M	D	M	L	L	L		L		L	L	L
	11	C	VC	C		VC		C	VC	C	M	D	M		M		M	D	M	L	L	L		L		L	L	L
	12	C	VC	C		VC		C	VC	C	M	D	M		M		M	D	M	L	L	L		L		L	L	L
Z	101	S	VS	M		S		M	M	M	D	D	M		D		D	D	D	T	T	T		T		T	L	T
	102	S	VS	M		S		M	M	M	D	D	M		D		D	D	D	T	T	T		T		T	L	T
	103	S	VS	M		S		M	M	M	D	D	M		D		D	D	D	T	T	T		T		T	L	T
	202	S	VS	M		S		M	M	M	D	D	M		D		D	D	D	T	T	T		T		T	L	T
	204	S	VS	M		S		M	M	M	D	D	M		D		D	D	D	T	T	T		T		T	L	T
	206	S	VS	M		S		M	M	M	D	D	M		D		D	D	D	T	T	T		T		T	L	T
	301	S	VS	M		S		M	S	S	D	D	D		D		D	D	D	T	T	T		T		T	L	T
	303	S	VS	M		S		M	M	M	D	D	D		D		D	D	D	T	T	T		T		T	L	T
	305	S	VS	M		S		M	M	M	D	D	D		D		D	D	D	T	T	T		T		T	L	T
	417	M	C	M		M		C	M	C	M	L	M		M		M	D	M	T	L	T		T		L	L	T
	418	M	C	M		M		C	M	C	M	L	M		M		M	D	M	T	L	T		T		L	L	T
	419	M	C	M		M		C	M	C	M	L	M		M		M	D	M	T	L	T		T		L	L	T
	501	S	VS	S		S		M	M	M	D	D	D		D		D	D	D	T	T	T		T		T	L	T
	502	S	VS	S		S		M	M	M	D	D	D		D		D	D	D	T	T	T		T		T	L	T
	504	S	VS	S		S		M	M	M	D	D	D		D		D	D	D	T	T	T		T		T	L	T
	602	S	VS	S		S		M	M	M	D	D	D		D		D	D	D	T	T	T		T		T	L	T
	603	S	VS	S		S		M	M	M	D	D	D		D		D	D	D	T	T	T		T		T	L	T
	604	S	VS	S		S		M	M	M	D	D	D		D		D	D	D	T	T	T		T		T	L	T
	702	S	VS	S		S		M	M	M	D	D	D		D		D	D	D	T	T	T		T		T	L	T
	705	S	VS	S		S		M	M	M	D	D	D		D		D	D	D	T	T	T		T		T	L	T
	707	S	VS	S		S		M	M	M	D	D	D		D		D	D	D	T	T	T		T		T	L	T
OOO*	26	M	C	M		C		C	C	C	M	L	M		L		L	L	L	T	L	TL		L		L	L	L
YY‡	1	C	VC	C		C		VC	C	VC	L	L	L		L		L	L	L	L	L	L		L		L	L	L
	2	C	VC	C		C		VC	C	VC	L	L	L		L		L	L	L	L	L	L		L		L	L	L
	3	C	VC	C		C		VC	C	VC	L	L	L		L		L	L	L	L	L	L		L		L	L	L

* Exposed 11-20-16.

‡ Exposed 6-1-17.

proaching Tight.
to Light.
proaching Loose.
" "
" "
" Tight.
" Loose.
" "
" "
" "
" Smooth.
" "

— SMITH —

Notes : None.

— WHEATON —

Notes : None.

James H. Gibboney
Chairman Inspection Committee

Date of Inspection *March 31, 1919.*

ROW No. 1

DESIGNATION		CONDITION OF RUST																										
		Texture									Color									Adherence								
Mark	Sheet No.	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9
AA	11	VC	VC		C	VC		C	M	M	L	M		L	L		L	M	M	L	L		M	L		L	T	T
	12	VC	VC		C	VC		C	M	M	L	M		L	L		L	M	M	L	L		M	L		L	T	T
	13	VC	VC		C	VC		C	M	M	L	M		L	L		L	M	M	L	L		M	L		L	T	T
BB	4	M	S		C	C		S	M	M	M	M		D	M		M	M	M	T	T		M	T		T	T	T
	5	M	S		C	C		S	M	M	M	M		D	M		M	M	M	T	T		M	T		T	T	T
	6	M	S		C	C		S	M	M	M	M		D	M		M	M	M	T	T		M	T		T	T	T
CC	2	M	M		C	M		M	M	M	M	M		D	M		L	M	M	T	T		T	T		T	T	T
	9	M	M		C	M		M	M	M	M	M		D	M		L	M	M	T	T		T	T		T	T	T
	10	M	M		C	M		M	M	M	M	M		D	M		L	M	M	T	T		T	T		T	T	T
DD	18	M	M		C	M		M	M	M	M	M		L	M		L	M	M	T	T		M	T		T	T	T
	19	M	M		C	M		M	M	M	M	M		L	M		L	M	M	T	T		M	T		T	T	T
	20	M	M		C	M		M	M	M	M	M		L	M		L	M	M	T	T		M	T		T	T	T
EE*	7	M	S		M	M		M	M	M	M	M		D	M		M	M	M	T	T		T	T		T	T	T
	8	M	S		M	M		M	M	M	M	M		D	M		M	M	M	T	T		T	T		T	T	T
	9	M	S		M	M		M	M	M	M	M		D	M		M	M	M	T	T		T	T		T	T	T
HH	10	M	S		S	M		S	S	M	M	M		D	D		D	D	M	T	T		T	T		T	T	T
	11	M	S		S	M		S	S	M	M	M		D	D		D	D	M	T	T		T	T		T	T	T
	12	M	S		S	M		S	S	M	M	M		D	D		D	D	M	T	T		T	T		T	T	T
II	10	M	VS		S	S		S	S	M	M	D		D	M		D	D	M	T	T		T	T		T	T	T
	11	M	VS		S	S		S	S	M	M	D		D	M		D	D	M	T	T		T	T		T	T	T
	12	M	VS		S	S		S	S	M	M	D		D	M		D	D	M	T	T		T	T		T	T	T
KK	4	M	VS		S	M		S	VS	M	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	5	M	VS		S	M		S	VS	M	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	18	M	VS		S	M		S	VS	M	M	D		D	M		D	M	M	T	T		T	T		T	T	T
MM*	15	M	S		M	M		M	M	C	M	D		D	M		M	M	M	T	T		M	T		T	T	T
	16	M	S		M	M		M	M	C	M	D		D	M		M	M	M	T	T		M	T		T	T	T
	17	M	S		M	M		M	M	C	M	D		D	M		M	M	M	T	T		M	T		T	T	T
SS	15	M	C		C	C		C	C	C	L	L		L	L		L	L	M	T	L		L	T		L	T	T
	16	M	C		C	C		C	C	C	L	L		L	L		L	L	M	T	L		L	T		L	T	T
	17	M	C		C	C		C	C	C	L	L		L	L		L	L	M	T	L		L	T		L	T	T
TT	15	M	VS		S	M		S	M	M	M	D		D	M		D	D	M	T	T		T	T		T	T	T
	16	M	VS		S	M		S	M	M	M	D		D	M		D	D	M	T	T		T	T		T	T	T
	17	M	VS		S	M		S	M	M	M	D		D	M		D	D	M	T	T		T	T		T	T	T
UU	15	M	S		M	M		S	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
	16	M	S		M	M		S	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
	17	M	S		M	M		S	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
VV	20	M	S		M	S		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
	21	M	S		M	S		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
	22	M	S		M	S		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
XX	15	M	M		C	M		C	C	M	M	M		M	M		M	L	M	T	T		M	T		L	T	T
	16	M	M		C	M		C	C	M	M	M		M	M		M	L	M	T	T		M	T		L	T	T
	17	M	M		C	M		C	C	M	M	M		M	M		M	L	M	T	T		M	T		L	T	T
OO	13	M	C		C	C		M	C	M	M	M		M	M		M	M	M	T	T		M	T		L	T	T
	14	M	C		C	C		M	C	M	M	M		M	M		M	M	M	T	T		M	T		L	T	T
	15	M	C		C	C		M	C	M	M	M		M	M		M	M	M	T	T		M	T		L	T	T
CCC	13	M	S		M	M		M	C	C	M	M		D	D		L	L	M	T	T		T	T		T	T	T
	14	M	S		M	M		M	C	C	M	M		D	D		L	L	M	T	T		T	T		T	T	T
	15	M	S		M	M		M	C	C	M	M		D	D		L	L	M	T	T		T	T		T	T	T

‡ Open Annealed.

ROW No. 2

DESIGNATION		CONDITION OF RUST																										
		Texture									Color									Adherence								
Mark	Sheet No.	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9
A	16	VC	VC		C	C		C	C	C	L	L		M	M		L	M	M	L	L		L	L		L	L	T
	17	VC	VC		C	C		C	C	C	L	L		M	M		L	M	M	L	L		L	L		L	L	T
	18	VC	VC		C	C		C	C	C	L	L		M	M		L	M	M	L	L		L	L		L	L	T
B	9	M	S		M	M		M	S	S	M	D		D	M		M	M	M	T	T		M	T		T	T	T
	10	M	S		M	M		M	S	S	M	D		D	M		M	M	M	T	T		M	T		T	T	T
	11	M	S		M	M		M	S	S	M	D		D	M		M	M	M	T	T		M	T		T	T	T
C	6	M	M		M	M		M	M	M	M	M		D	M		M	M	M	T	T		T	T		L	T	T
	7	M	M		M	M		M	M	M	M	M		D	M		M	M	M	T	T		T	T		L	T	T
	8	M	M		M	M		M	M	M	M	M		D	M		M	M	M	T	T		T	T		L	T	T
D	16	M	C		C	C		M	C	M	M	M		L	L		L	M	M	T	L		L	T		L	T	T
	19	M	C		C	C		M	C	M	M	M		L	L		L	M	M	T	L		L	T		L	T	T
	22	M	C		C	C		M	C	M	M	M		L	L		L	M	M	T	L		L	T		L	T	T
E	13	S	M		M	M		S	M	M	M	M		D	M		M	M	M	T	T		T	T		T	T	T
	14	S	M		M	M		S	M	M	M	M		D	M		M	M	M	T	T		T	T		T	T	T
	15	S	M		M	M		S	M	M	M	M		D	M		M	M	M	T	T		T	T		T	T	T
H	19	S	S		M	S		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	20	S	S		M	S		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	22	S	S		M	S		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
I	19	S	VS		M	S		S	S	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	20	S	VS		M	S		S	S	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	21	S	VS		M	S		S	S	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
K	17	S	VS		M	S		S	S	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	18	S	VS		M	S		S	S	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	19	S	VS		M	S		S	S	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	15	S	M		M	M		M	M	S	M	M		D	M		M	M	M	T	T		T	T		T	T	T
	16	S	M		M	M		M	M	S	M	M		M	M		M	M	M	T	T		T	T		T	T	T
	17	S	M		M	M		M	M	S	M	M		M	M		M	M	M	T	T		T	T		T	T	T
S	15	M	C		C	C		C	M	C	M	L		L	L		L	M	M	T	L		L	T		L	T	T
	16	M	C		C	C		C	M	C	M	L		L	L		L	M	M	T	L		L	T		L	T	T
	17	M	C		C	C		C	M	C	M	L		L	L		L	M	M	T	L		L	T		L	T	T
T	15	M	S		M	M		M	M	M	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	16	M	S		M	M		M	M	M	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	17	M	S		M	M		M	M	M	M	D		D	M		D	M	M	T	T		T	T		T	T	T
U	15	M	S		M	S		M	M	M	M	D		M	M		D	M	M	T	T		T	T		T	T	T
	16	M	S		M	S		M	M	M	M	D		M	M		D	M	M	T	T		T	T		T	T	T
	17	M	S		M	S		M	M	M	M	D		M	M		D	M	M	T	T		T	T		T	T	T
V	15	M	S		M	M		M	M	M	M	D		M	M		D	M	M	T	T		T	T		T	T	T
	16	M	S		M	M		M	M	M	M	D		M	M		D	M	M	T	T		T	T		T	T	T
	17	M	S		M	M		M	M	M	M	D		M	M		D	M	M	T	T		T	T		T	T	T
X	15	M	C		C	C		C	M	M	M	L		D	M		M	M	M	T	L		L	T		L	T	T
	16	M	C		C	C		C	M	M	M	L		D	M		M	M	M	T	L		L	T		L	T	T
	17	M	C		C	C		C	M	M	M	L		D	M		M	M	M	T	L		L	T		L	T	T
O	13	C	VC		C	VC		M	C	C	M	L		M	D		M	M	M	L	L		L	L		L	T	T
	14	C	VC		C	VC		M	C	C	M	L		M	D		M	M	M	L	L		L	L		L	T	T
	15	C	VC		C	VC		M	C	C	M	L		M	D		M	M	M	L	L		L	L		L	T	T
Z	4	M	C		C	C		M		C	M	L		L	M		M		M	T	L		L	L		L		T
	5	M	C		C	C		M		C	M	L		L	M		M		M	T	L		L	L		L		T
	109	M	C		S	VS		S		M	M	D		D	D		D		M	T	T		T	T		T		T

ROW No. 3

DESIGNATION		CONDITION OF RUST																						
		Texture									Color									Adherence				
Mark	Sheet No.	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5
AA	14	C	VC		C	VC		C	VC	M	L	L		L	L		L	M	M	L	L		L	L
	15	C	VC		C	VC		C	VC	M	L	L		L	L		L	M	M	L	L		L	L
	16	C	VC		C	VC		C	VC	M	L	L		L	L		L	M	M	L	L		L	L
	17	C	VC		C	VC		C	VC	M	L	L		L	L		L	M	M	L	L		L	L
	18	C	VC		C	VC		C	VC	M	L	L		L	L		L	M	M	L	L		L	L
	19	C	VC		C	VC		C	VC	M	L	L		L	L		L	M	M	L	L		L	L
	20	C	VC		C	VC		C	VC	M	L	L		L	L		L	M	M	L	L		L	L
AA*	42	C	VC		C	C		C	C	C	L	L		L	M		L	M	M	L	L		L	T
	43	C	VC		C	C		C	C	C	L	L		L	M		L	M	M	L	L		L	T
	44	C	VC		C	C		C	C	C	L	L		L	M		L	M	M	L	L		L	T
	45	C	VC		C	C		C	C	C	L	L		L	M		L	M	M	L	L		L	T
	46	C	VC		C	C		C	C	C	L	L		L	M		L	M	M	L	L		L	T
	47	C	VC		C	C		C	C	C	L	L		L	M		L	M	M	L	L		L	T
	48	C	VC		C	C		C	C	C	L	L		L	M		L	M	M	L	L		L	T
	49	C	VC		C	C		C	C	C	L	L		L	M		L	M	M	L	L		L	T
BB	7	M	S		M	M		M	M	M	M	D		M	M		D	M	M	T	T		T	T
	15	M	S		M	M		M	M	M	M	D		M	M		D	M	M	T	T		T	T
	16	M	S		M	M		M	M	M	M	D		M	M		D	M	M	T	T		T	T
	17	M	S		M	M		M	M	M	M	D		M	M		D	M	M	T	T		T	T
	18	M	S		M	M		M	M	M	M	D		M	M		D	M	M	T	T		T	T
	19	M	S		M	M		M	M	M	M	D		M	M		D	M	M	T	T		T	T
BB*	29	M	S		M	S		M	S	M	M	D		M	M		D	M	M	T	T		T	T
	30	M	S		M	S		M	S	M	M	D		M	M		D	M	M	T	T		T	T
	31	M	S		M	S		M	S	M	M	D		M	M		D	M	M	T	T		T	T
	32	M	S		M	S		M	S	M	M	D		M	M		D	M	M	T	T		T	T
	46	M	S		M	S		M	S	M	M	D		M	M		D	M	M	T	T		T	T
	47	M	S		M	S		M	S	M	M	D		M	M		D	M	M	T	T		T	T
	48	M	S		M	S		M	S	M	M	D		M	M		D	M	M	T	T		T	T
	49	M	S		M	S		M	S	M	M	D		M	M		D	M	M	T	T		T	T
CC	11	M	M		M	C		C	M	C	M	M		D	L		L	M	M	T	T		T	T
	12	M	M		M	C		C	M	C	M	M		D	L		L	M	M	T	T		T	T
	13	M	M		M	C		C	M	C	M	M		D	L		L	M	M	T	T		T	T
	14	M	M		M	C		C	M	C	M	M		D	L		L	M	M	T	T		T	T
CC*	26	M	M		M	C		C	C	C	M	M		D	M		L	M	M	T	T		T	T
	27	M	M		M	C		C	C	C	M	M		D	M		L	M	M	T	T		T	T
	28	M	M		M	C		C	C	C	M	M		D	M		L	M	M	T	T		T	T
	29	M	M		M	C		C	C	C	M	M		D	M		L	M	M	T	T		T	T
	30	M	M		M	C		C	C	C	M	M		D	M		L	M	M	T	T		T	T
DD	5	M	C		M	C		C	C	C	M	M		M	M		L	M	M	T	T		M	T
	6	M	C		M	C		C	C	C	M	M		M	M		L	M	M	T	T		M	T
	7	M	C		M	C		C	C	C	M	M		M	M		L	M	M	T	T		M	T
	21	M	C		M	C		C	C	C	M	M		M	M		L	M	M	T	T		M	T
	22	M	C		M	C		C	C	C	M	M		M	M		L	M	M	T	T		M	T
	23	M	C		M	C		C	C	C	M	M		M	M		L	M	M	T	T		M	T
	24	M	C		M	C		C	C	C	M	M		M	M		L	M	M	T	T		M	T
YY†	6	M	C		C	C		VC	M	C	M	M		L	L		L	M	M	T	T		L	T
	4	M	C		C	C		VC	M	C	M	M		L	L		L	M	M	T	T		L	T
	5	M	C		C	C		VC	M	C	M	M		L	L		L	M	M	T	T		L	T
Y†	4	M	M		C	M		C	M	C	M	M		L	M		L	M	M	T	T		L	T

* Sand Blasted.

† Exposed 6-13-17.

— INSPECTION COMMITTEE —

J. H. Gibboney, Chairman — Norfolk & Western R.R.
J. A. Aupperle — American Rolling Mill Co.
D. M. Buck — American Sheet & Tin Plate Co.
W. A. Cooper — Alan Wood Iron & Steel Co.
W. R. Fleming — The Andrews Steel Co.
D. J. McAdam, Jr. — U.S. Navy, Bureau Steam Engineering.
M. E. McDonnell — Pennsylvania Railroad.
H. E. Smith — U.S. Railroad Administration.
F. B. Wheaton — U.S. Army, Quartermaster's Corps.

CONDITION OF RUST.

Texture	Color	Adherence
VS—Very Smooth	L—Light	T—Tight
S—Smooth	M—Medium	L—Loose
M—Medium	D—Dark	
C—Coarse		
VC—Very Coarse		

— GENERAL —

Sheets H 19, 20, 22
" I 19-21 incl.
" K 17-19 "
" M 15-17 "
" S 15-17 "
" T 15-17 "
" U 15-17 "
" V 15-17 "
" X 15-17 "
" O 13-15 "
" Z 4, 5, 109

Sheets Largely Covered with Snow. The Record given is the Best Obtainable from the Small Areas Exposed.

Some Sheets in Row No. 3 partially Covered with Snow not Sufficient to interfere with obtaining Satisfactory Record.

Table III.—Results of Inspection of Corrosion Test Sheets, at Fort Sheridan, Ill.,

1919.

AMERICAN SOCIETY FOR TESTING MATERIALS
COMMITTEE A-5 ON CORROSION OF IRON AND STEEL
TESTS OF UNCOATED SHEETS
FORT SHERIDAN, ILL.

EXPOSED APRIL 9, 1917

Adherence						
Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9
	L	L		L	L	T
	L	L		L	L	T
	L	L		L	L	T
	L	L		L	L	T
	L	L		L	L	T
	L	L		L	L	T
	L	L		L	L	T
	L	T		L	L	T
	L	T		L	L	T
	L	T		L	L	T
	L	T		L	L	T
	L	T		L	L	T
	L	T		L	L	T
	L	T		L	L	T
	L	T		L	L	T
	T	T		T	T	T
	T	T		T	T	T
	T	T		T	T	T
	T	T		T	T	T
	T	T		T	T	T
	T	T		T	T	T
	T	T		T	T	T
	T	T		T	T	T
	T	T		T	T	T
	T	T		T	T	T
	T	T		T	T	T
	T	T		T	T	T
	T	T		T	T	T
	T	T		T	T	T
	T	T		L	T	T
	T	T		L	T	T
	T	T		L	T	T
	T	T		L	T	T
	T	T		L	T	T
	T	T		L	T	T
	T	T		L	T	T
	T	T		L	T	T
	T	T		L	T	T
	M	T		L	T	T
	M	T		L	T	T
	M	T		L	T	T
	M	T		L	T	T
	M	T		L	T	T
	M	T		L	T	T
	M	T		L	T	T
	L	T		L	T	T
	L	T		L	T	T
	L	T		L	T	T
	L	T		L	T	T

ROW No. 4

DESIGNATION		CONDITION OF RUST																										
		Texture									Color									Adherence								
Mark	Sheet No.	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9
DD*	39	M	M		M	M		M	S	M	M	M		L	M		L	L	M	T	T		L	T		L	T	T
	40	M	M		M	M		M	S	M	M	M		L	M		L	L	M	T	T		L	T		L	T	T
	44	M	M		M	M		M	S	M	M	M		L	M		L	L	M	T	T		L	T		L	T	T
	45	M	M		M	M		M	S	M	M	M		L	M		L	L	M	T	T		L	T		L	T	T
	46	M	M		M	M		M	S	M	M	M		L	M		L	L	M	T	T		L	T		L	T	T
	50	M	M		M	M		M	S	M	M	M		L	M		L	L	M	T	T		L	T		L	T	T
	51	M	M		M	M		M	S	M	M	M		L	M		L	L	M	T	T		L	T		L	T	T
	52	M	M		M	M		M	S	M	M	M		L	M		L	L	M	T	T		L	T		L	T	T
	53	M	M		M	M		M	S	M	M	M		L	M		L	L	M	T	T		L	T		L	T	T
EE†	10	S	S		M	C		M	M	M	M	D		D	M		M	M	M	T	T		T	T		T	T	T
	11	S	S		M	C		M	M	M	M	D		D	M		M	M	M	T	T		T	T		T	T	T
	12	S	S		M	C		M	M	M	M	D		D	M		M	M	M	T	T		T	T		T	T	T
EE*†	25	S	S		M	M		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	26	S	S		M	M		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	27	S	S		M	M		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	28	S	S		M	M		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	29	S	S		M	M		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	30	S	S		M	M		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
HH	13	S	S		S	S		S	M	M	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	14	S	S		S	S		S	M	M	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	15	S	S		S	S		S	M	M	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	16	S	S		S	S		S	M	M	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	17	S	S		S	S		S	M	M	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	18	S	S		S	S		S	M	M	M	D		D	M		D	M	M	T	T		T	T		T	T	T
HH*	35	S	S		S	S		S	S	M	M	D		D	D		D	M	M	T	T		T	T		T	T	T
	36	S	S		S	S		S	S	M	M	D		D	D		D	M	M	T	T		T	T		T	T	T
	37	S	S		S	S		S	S	M	M	D		D	D		D	M	M	T	T		T	T		T	T	T
	38	S	S		S	S		S	S	M	M	D		D	D		D	M	M	T	T		T	T		T	T	T
	39	S	S		S	S		S	S	M	M	D		D	D		D	M	M	T	T		T	T		T	T	T
	40	S	S		S	S		S	S	M	M	D		D	D		D	M	M	T	T		T	T		T	T	T
	41	S	S		S	S		S	S	M	M	D		D	D		D	M	M	T	T		T	T		T	T	T
	42	S	S		S	S		S	S	M	M	D		D	D		D	M	M	T	T		T	T		T	T	T
II	13	S	VS		S	S		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	14	S	VS		S	S		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	15	S	VS		S	S		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	16	S	VS		S	S		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	17	S	VS		S	S		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	18	S	VS		S	S		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	19	S	VS		S	S		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
II*	39	S	VS		S	S		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	40	S	VS		S	S		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	41	S	VS		S	S		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	42	S	VS		S	S		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	43	S	VS		S	S		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	44	S	VS		S	S		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	45	S	VS		S	S		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	46	S	VS		S	S		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	47	S	VS		S	S		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T

* Sand Blasted.
† Open Annealed.

ROW No. 5

DESIGNATION		CONDITION OF RUST																										
		Texture									Color									Adherence								
Mark	Sheet No.	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9
KK	19	S	VS		S	S		S	S	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	20	S	VS		S	S		S	S	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	21	S	VS		S	S		S	S	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	22	S	VS		S	S		S	S	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	23	S	VS		S	S		S	S	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	24	S	VS		S	S		S	S	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	25	S	VS		S	S		S	S	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	26	S	VS		S	S		S	S	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
KK*	43	S	VS		S	S		S	S	S	M	D		D	D		D	M	M	T	T		T	T		T	T	T
	44	S	VS		S	S		S	S	S	M	D		D	D		D	M	M	T	T		T	T		T	T	T
	45	S	VS		S	S		S	S	S	M	D		D	D		D	M	M	T	T		T	T		T	T	T
	46	S	VS		S	S		S	S	S	M	D		D	D		D	M	M	T	T		T	T		T	T	T
	47	S	VS		S	S		S	S	S	M	D		D	D		D	M	M	T	T		T	T		T	T	T
	48	S	VS		S	S		S	S	S	M	D		D	D		D	M	M	T	T		T	T		T	T	T
	49	S	VS		S	S		S	S	S	M	D		D	D		D	M	M	T	T		T	T		T	T	T
	50	S	VS		S	S		S	S	S	M	D		D	D		D	M	M	T	T		T	T		T	T	T
MM†	18	M	C		M	C		M	C	M	M	M		M	L		M	M	M	T	L		T	T		T	T	T
	19	M	C		M	C		C	C	M	M	M		M	L		M	M	M	T	L		T	T		T	T	T
	20	M	C		M	C		C	C	M	M	M		M	L		M	M	M	T	L		T	T		T	T	T
	21	M	C		M	C		M	C	M	M	M		M	L		M	M	M	T	L		T	T		T	T	T
	22	M	C		M	C		M	C	M	M	M		M	L		M	M	M	T	L		T	T		T	T	T
	23	M	C		M	C		M	C	M	M	M		M	L		M	M	M	T	L		T	T		T	T	T
	24	M	C		M	C		M	C	M	M	M		M	L		M	M	M	T	L		T	T		T	T	T
	25	M	C		M	C		M	C	M	M	M		M	L		M	M	M	T	L		T	T		T	T	T
	26	M	C		M	C		M	C	M	M	M		M	L		M	M	M	T	L		T	T		T	T	T
	27	M	C		M	C		M	C	M	M	M		M	L		M	M	M	T	L		T	T		T	T	T
	28	M	C		M	C		M	C	M	M	M		M	L		M	M	M	T	L		T	T		T	T	T
SS	18	M	C		C	C		C	C	C	L	L		L	L		L	L	M	T	L		L	T		L	T	T
	19	M	C		C	C		C	C	C	L	L		L	L		L	L	M	T	L		L	T		L	T	T
	20	M	C		C	C		C	C	C	L	L		L	L		L	L	M	T	L		L	T		L	T	T
	22	M	C		C	C		C	C	C	L	L		L	L		L	L	M	T	L		L	T		L	T	T
	23	M	C		C	C		C	C	C	L	L		L	L		L	L	M	T	L		L	T		L	T	T
	24	M	C		C	C		C	C	C	L	L		L	L		L	L	M	T	L		L	T		L	T	T
	25	M	C		C	C		C	C	C	L	L		L	L		L	L	M	T	L		L	T		L	T	T
	26	M	C		C	C		C	C	C	L	L		L	L		L	L	M	T	L		L	T		L	T	T
	27	M	C		C	C		C	C	C	L	L		L	L		L	L	M	T	L		L	T		L	T	T
TT	18	S	S		S	M		S	M	M	D	D		D	D		D	M	M	T	T		T	T		T	T	T
	19	S	S		S	M		S	M	M	D	D		D	D		D	M	M	T	T		T	T		T	T	T
	20	S	S		S	M		S	M	M	D	D		D	D		D	M	M	T	T		T	T		T	T	T
	21	S	S		S	M		S	M	M	D	D		D	D		D	M	M	T	T		T	T		T	T	T
	22	S	S		S	M		S	M	M	D	D		D	D		D	M	M	T	T		T	T		T	T	T
	23	S	S		S	M		S	M	M	D	D		D	D		D	M	M	T	T		T	T		T	T	T
	24	S	S		S	M		S	M	M	D	D		D	D		D	M	M	T	T		T	T		T	T	T
	25	S	S		S	M		S	M	M	D	D		D	D		D	M	M	T	T		T	T		T	T	T
	26	S	S		S	M		S	M	M	D	D		D	D		D	M	M	T	T		T	T		T	T	T
	27	S	S		S	M		S	M	M	D	D		D	D		D	M	M	T	T		T	T		T	T	T
	28	S	S		S	M		S	M	M	D	D		D	D		D	M	M	T	T		T	T		T	T	T
Y‡	6	C	C		C	C		VC	C	C	L	L		L	L		M	L	M	L	L		L	T		L	T	T
	5	C	C		C	C		VC	C	C	L	L		L	L		M	L	M	L	L		L	T		L	T	T

* Sand Blasted.
† Open Annealed.
‡ Exposed 6-13-17.

ROW No. 6

DESIGNATION		CONDITION OF RUST																								
		Texture									Color									Adherence						
Mark	Sheet No.	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7
UU	18	M	S		M	M		S	M	M	M	M		D	M		D	M	M	T	T		T	T		T
	19	M	S		M	M		S	M	M	M	M		D	M		D	M	M	T	T		T	T		T
	20	M	S		M	M		S	M	M	M	M		D	M		D	M	M	T	T		T	T		T
	22	M	S		M	M		S	M	M	M	M		D	M		D	M	M	T	T		T	T		T
	23	M	S		M	M		S	M	M	M	M		D	M		D	M	M	T	T		T	T		T
	24	M	S		M	M		S	M	M	M	M		D	M		D	M	M	T	T		T	T		T
	25	M	S		M	M		S	M	M	M	M		D	M		D	M	M	T	T		T	T		T
	26	M	S		M	M		S	M	M	M	M		D	M		D	M	M	T	T		T	T		T
	27	M	S		M	M		S	M	M	M	M		D	M		D	M	M	T	T		T	T		T
	28	M	S		M	M		S	M	M	M	M		D	M		D	M	M	T	T		T	T		T
VV	23	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T
	24	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T
	25	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T
	26	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T
	27	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T
	28	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T
	29	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T
	30	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T
	31	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T
	32	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T
	33	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T
	34	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T
	35	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T
	36	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T
	37	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T
	38	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T
XX	18	C	C		C	C		C	C	C	L	L		M	M		L	L	M	T	L		T	T		L
	19	C	C		C	C		C	C	C	L	L		M	M		L	L	M	T	L		T	T		L
	20	C	C		C	C		C	C	C	L	L		M	M		L	L	M	T	L		T	T		L
	21	C	C		C	C		C	C	C	L	L		M	M		L	L	M	T	L		T	T		L
	22	C	C		C	C		C	C	C	L	L		M	M		L	L	M	T	L		T	T		L
	23	C	C		C	C		C	C	C	L	L		M	M		L	L	M	T	L		T	T		L
	24	C	C		C	C		C	C	C	L	L		M	M		L	L	M	T	L		T	T		L
	25	C	C		C	C		C	C	C	L	L		M	M		L	L	M	T	L		T	T		L
	26	C	C		C	C		C	C	C	L	L		M	M		L	L	M	T	L		T	T		L
	27	C	C		C	C		C	C	C	L	L		M	M		L	L	M	T	L		T	T		L
	28	C	C		C	C		C	C	C	L	L		M	M		L	L	M	T	L		T	T		L
ZZ	5	C	C		M	M		C	C	C	L	L		L	L		L	L	M	L	L		L	T		L
	7	C	C		M	M		C	C	C	L	L		L	L		L	L	M	L	L		L	T		L
	308	VS	VS		S	S		S	VS	M	D	D		D	D		D	D	M	T	T		T	T		T
	309	VS	VS		S	S		S	VS	M	D	D		D	D		D	D	M	T	T		T	T		T
	505	M	VS		S	S		S	M	M	D	D		D	M		D	M	M	T	T		T	T		T
	506	M	VS		S	S		S	M	M	D	D		D	M		D	M	M	T	T		T	T		T
	610	VS	VS		S	VS		S	M	S	D	D		D	D		D	M	M	T	T		T	T		T
	611	VS	VS		S	VS		S	M	S	D	D		D	D		D	M	M	T	T		T	T		T

ly Covered
he Record
est Obtain-
Small
sed.

now not
Record.

— AUPPERLE —
Notes : None.

— BUCK —
Notes : None.

— COOPER —
Did not make this Inspection.

— FLEMING —
Notes : None.

— GIBBONEY —
Notes : None.

— MC ADAM
Did not ma
this Inspecti

ion of Corrosion Test Sheets, at Fort Sheridan, Ill., March 31, 1919.

RICAN SOCIETY FOR TESTING MATERIALS

COMMITTEE A-5 ON CORROSION OF IRON AND STEEL
TESTS OF UNCOATED SHEETS
FORT SHERIDAN, ILL.

EXPOSED APRIL 9, 1917

Weather *Cold and Cloudy*

CONDITION OF RUST

Color									Adherence								
1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton
M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	D		D	D		D	M	M	T	T		T	T		T	T	T
M	D		D	D		D	M	M	T	T		T	T		T	T	T
M	D		D	D		D	M	M	T	T		T	T		T	T	T
M	D		D	D		D	M	M	T	T		T	T		T	T	T
M	D		D	D		D	M	M	T	T		T	T		T	T	T
M	D		D	D		D	M	M	T	T		T	T		T	T	T
M	D		D	D		D	M	M	T	T		T	T		T	T	T
M	D		D	D		D	M	M	T	T		T	T		T	T	T
M	M		M	L		M	M	M	T	L		T	T		T	T	T
M	M		M	L		M	M	M	T	L		T	T		T	T	T
M	M		M	L		M	M	M	T	L		T	T		T	T	T
M	M		M	L		M	M	M	T	L		T	T		T	T	T
M	M		M	L		M	M	M	T	L		T	T		T	T	T
M	M		M	L		M	M	M	T	L		T	T		T	T	T
M	M		M	L		M	M	M	T	L		T	T		T	T	T
M	M		M	L		M	M	M	T	L		T	T		T	T	T
M	M		M	L		M	M	M	T	L		T	T		T	T	T
M	M		M	L		M	M	M	T	L		T	T		T	T	T
M	M		M	L		M	M	M	T	L		T	T		T	T	T
L	L		L	L		L	L	M	T	L		L	T		L	T	T
L	L		L	L		L	L	M	T	L		L	T		L	T	T
L	L		L	L		L	L	M	T	L		L	T		L	T	T
L	L		L	L		L	L	M	T	L		L	T		L	T	T
L	L		L	L		L	L	M	T	L		L	T		L	T	T
L	L		L	L		L	L	M	T	L		L	T		L	T	T
L	L		L	L		L	L	M	T	L		L	T		L	T	T
L	L		L	L		L	L	M	T	L		L	T		L	T	T
L	L		L	L		L	L	M	T	L		L	T		L	T	T
D	D		D	D		D	M	M	T	T		T	T		T	T	T
D	D		D	D		D	M	M	T	T		T	T		T	T	T
D	D		D	D		D	M	M	T	T		T	T		T	T	T
D	D		D	D		D	M	M	T	T		T	T		T	T	T
D	D		D	D		D	M	M	T	T		T	T		T	T	T
D	D		D	D		D	M	M	T	T		T	T		T	T	T
D	D		D	D		D	M	M	T	T		T	T		T	T	T
D	D		D	D		D	M	M	T	T		T	T		T	T	T
D	D		D	D		D	M	M	T	T		T	T		T	T	T
D	D		D	D		D	M	M	T	T		T	T		T	T	T
D	D		D	D		D	M	M	T	T		T	T		T	T	T
L	L		L	L		M	L	M	L	L		L	T		L	T	T
L	L		L	L		M	L	M	L	L		L	T		L	T	T

ROW No. 6

Designation		Texture									Condition of Rust																	
Mark	Sheet No.										Color									Adherence								
		1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton
UU	18	M	S		M	M		S	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
	19	M	S		M	M		S	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
	20	M	S		M	M		S	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
	22	M	S		M	M		S	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
	23	M	S		M	M		S	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
	24	M	S		M	M		S	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
	25	M	S		M	M		S	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
	26	M	S		M	M		S	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
	27	M	S		M	M		S	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
	28	M	S		M	M		S	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
VV	23	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
	24	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
	25	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
	26	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
	27	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
	28	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
	29	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
	30	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
	31	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
	32	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
	33	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
	34	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
	35	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
	36	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
	37	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
	38	S	S		M	M		M	M	M	M	M		D	M		D	M	M	T	T		T	T		T	T	T
XX	18	C	C		C	C		C	C	C	L	L		M	M		L	L	M	T	L		T	T		L	T	T
	19	C	C		C	C		C	C	C	L	L		M	M		L	L	M	T	L		T	T		L	T	T
	20	C	C		C	C		C	C	C	L	L		M	M		L	L	M	T	L		T	T		L	T	T
	21	C	C		C	C		C	C	C	L	L		M	M		L	L	M	T	L		T	T		L	T	T
	22	C	C		C	C		C	C	C	L	L		M	M		L	L	M	T	L		T	T		L	T	T
	23	C	C		C	C		C	C	C	L	L		M	M		L	L	M	T	L		T	T		L	T	T
	24	C	C		C	C		C	C	C	L	L		M	M		L	L	M	T	L		T	T		L	T	T
	25	C	C		C	C		C	C	C	L	L		M	M		L	L	M	T	L		T	T		L	T	T
	26	C	C		C	C		C	C	C	L	L		M	M		L	L	M	T	L		T	T		L	T	T
	27	C	C		C	C		C	C	C	L	L		M	M		L	L	M	T	L		T	T		L	T	T
	28	C	C		C	C		C	C	C	L	L		M	M		L	L	M	T	L		T	T		L	T	T
ZZ	5	C	C		M	M		C	C	C	L	L		L	L		L	L	M	L	L		L	T		L	T	T
	7	C	C		M	M		C	C	C	L	L		L	L		L	L	M	L	L		L	T		L	T	T
	308	VS	VS		S	S		S	VS	M	D	D		D	D		D	D	M	T	T		T	T		T	T	T
	309	VS	VS		S	S		S	VS	M	D	D		D	D		D	D	M	T	T		T	T		T	T	T
	505	M	VS		S	S		S	M	M	D	D		D	M		D	M	M	T	T		T	T		T	T	T
	506	M	VS		S	S		S	M	M	D	D		D	M		D	M	M	T	T		T	T		T	T	T
	610	VS	VS		S	VS		S	M	S	D	D		D	D		D	M	M	T	T		T	T		T	T	T
	611	VS	VS		S	VS		S	M	S	D	D		D	D		D	M	M	T	T		T	T		T	T	T

ROW No. 7

Designation		Texture									Condition of Rust																	
Mark	Sheet No.										Color									Adherence								
		1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton
ZZ	108	VS	VS		S	S		S	S	S	D	D		D	D		D	M	M	T	T		T	T		T	T	T
	205	VS	VS		S	S		S	S	S	D	D		D	D		D	M	M	T	T		T	T		T	T	T
	206	VS	VS		S	S		S	S	S	D	D		D	D		D	M	M	T	T		T	T		T	T	T
	120	M	C		M	C		M	M	S	M	M		L	M		L	L	M	T	L		L	T		L	T	T
	122	M	C		M	C		M	M	S	M	M		L	M		L	L	M	T	L		L	T		L	T	T
	212	VS	VS		S	M		S	S	S	D	D		D	M		D	M	M	T	T		T	T		T	T	T
	213	VS	VS		S	M		S	S	S	D	D		D	M		D	M	M	T	T		T	T		T	T	T
OO	16	M	C		M	M		C	M	M	M	M		L	L		L	M	M	T	L		L	T		L	T	T
	17	M	C		M	M		C	M	M	M	M		L	L		L	M	M	T	L		L	T		L	T	T
	18	M	C		M	M		C	M	M	M	M		L	L		L	M	M	T	L		L	T		L	T	T
	19	M	C		M	M		C	M	M	M	M		L	L		L	M	M	T	L		L	T		L	T	T
	20	M	C		M	M		C	M	M	M	M		L	L		L	M	M	T	L		L	T		L	T	T
	21	M	C		M	M		C	M	M	M	M		L	L		L	M	M	T	L		L	T		L	T	T
	22	M	C		M	M		C	M	M	M	M		L	L		L	M	M	T	L		L	T		L	T	T
	23	M	C		M	M		C	M	M	M	M		L	L		L	M	M	T	L		L	T		L	T	T
	24	M	C		M	M		C	M	M	M	M		L	L		L	M	M	T	L		L	T		L	T	T
CCC	16	M	C		M	C		M	M	M	M	M		D	M		L	L	M	T	L		T	T		L	T	T
	17	M	C		M	C		M	M	M	M	M		D	M		L	L	M	T	L		T	T		L	T	T
	18	M	C		M	C		M	M	M	M	M		D	M		L	L	M	T	L		T	T		L	T	T
	19	M	C		M	C		M	M	M	M	M		D	M		L	L	M	T	L		T	T		L	T	T
	20	M	C		M	C		M	M	M	M	M		D	M		L	L	M	T	L		T	T		L	T	T
	21	M	C		M	C		M	M	M	M	M		D	M		L	L	M	T	L		T	T		L	T	T
	22	M	C		M	C		M	M	M	M	M		D	M		L	L	M	T	L		T	T		L	T	T
	23	M	C		M	C		M	M	M	M	M		D	M		L	L	M	T	L		T	T		L	T	T
	24	M	C		M	C		M	M	M	M	M		D	M		L	L	M	T	L		T	T		L	T	T
A	19	M	VC		C	VC		C	C	C	M	L		L	L		L	M	M	L	L		L	L		L	T	T
	20	M	VC		C	VC		C	C	C	M	L		L	L		L	M	M	L	L		L	L		L	T	T
	21	M	VC		C	VC		C	C	C	M	L		L	L		L	M	M	L	L		L	L		L	T	T
	22	M	VC		C	VC		C	C	C	M	L		L	L		L	M	M	L	L		L	L		L	T	T
	23	M	VC		C	VC		C	C	C	M	L		L	L		L	M	M	L	L		L	L		L	T	T
	24	M	VC		C	VC		C	C	C	M	L		L	L		L	M	M	L	L		L	L		L	T	T
	25	M	VC		C	VC		C	C	C	M	L		L	L		L	M	M	L	L		L	L		L	T	T
	26	M	VC		C	VC		C	C	C	M	L		L	L		L	M	M	L	L		L	L		L	T	T
	27	M	VC		C	VC		C	C	C	M	L		L	L		L	M	M	L	L		L	L		L	T	T
	28	M	VC		C	VC		C	C	C	M	L		L	L		L	M	M	L	L		L	L		L	T	T
	29	M	VC		C	VC		C	C	C	M	L		L	L		L	M	M	L	L		L	L		L	T	T
	30	M	VC		C	VC		C	C	C		L		L	L		L	M	M	L	L		L	L		L	T	T
B	12	M	S		M	M		M	M	M	M	M		M	M		M	M	M	T	T		T	T		T	T	T
	13	M	S		M	M		M	M	M	M	M		M	M		M	M	M	T	T		T	T		T	T	T
	14	M	S		M	M		M	M	M	M	M		M	M		M	M	M	T	T		T	T		T	T	T
	15	M	S		M	M		M	M	M	M	M		M	M		M	M	M	T	T		T	T		T	T	T
	16	M	S		M	M		M	M	M	M	M		M	M		M	M	M	T	T		T	T		T	T	T
	29	M	S		M	M		M	M	M	M	M		M	M		M	M	M	T	T		T	T		T	T	T
	30	M	S		M	M		M	M	M	M	M		M	M		M	M	M	T	T		T	T		T	T	T
	31	M	S		M	M		M	M	M	M	M		M	M		M	M	M	T	T		T	T		T	T	T
	32	M	S		M	M		M	M	M	M	M		M	M		M	M	M	T	T		T	T		T	T	T
	33	M	S		M	M		M	M	M	M	M		M	M		M	M	M	T	T		T	T		T	T	T
Z	710	VS	VS		S	VS		S	M	M	D	D		D	D		D	M	M	T	T		T	T		T	T	T

ROW No. 8

Designation		Texture								
Mark	Sheet No.	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton
C	9	M	S		M	M		M	S	M
	10	M	S		M	M		M	S	M
	14	M	S		M	M		M	S	M
	19	M	S		M	M		M	S	M
	27	M	S		M	M		M	S	M
	28	M	S		M	M		M	S	M
	29	M	S		M	M		M	S	M
	30	M	S		M	M		M	S	M
	31	M	S		M	M		M	S	M
D	24	M	M		M	M		C	C	M
	25	M	M		M	M		C	C	M
	28	M	M		M	M		C	C	M
E	16	S	S		M	M		M	M	M
	17	S	S		M	M		M	M	M
	18	S	S		M	M		M	M	M
	19	S	S		M	M		M	M	M
	20	S	S		M	M		M	M	M
	21	S	S		M	M		M	M	M
	22	S	S		M	M		M	M	M
	23	S	S		M	M		M	M	M
	24	S	S		M	M		M	M	M
H	23	S	S		M	S		S	M	M
	24	S	S		M	S		S	M	M
	25	S	S		M	S		S	M	M
	28	S	S		M	S		S	M	M
	29	S	S		M	S		S	M	M
	33	S	S		M	S		S	M	M
	35	S	S		M	S		S	M	M
	36	S	S		M	S		S	M	M
I	22	S	VS		S	S		S	M	S
	23	S	VS		S	S		S	M	S
	24	S	VS		S	S		S	M	S
	25	S	VS		S	S		S	M	S
	26	S	VS		S	S		S	M	S
	27	S	VS		S	S		S	M	S
	28	S	VS		S	S		S	M	S
	29	S	VS		S	S		S	M	S
	30	S	VS		S	S		S	M	S
	31	S	VS		S	S		S	M	S
	32	S	VS		S	S		S	M	S
	33	S	VS		S	S		S	M	S
	34	S	VS		S	S		S	M	S
	35	S	VS		S	S		S	M	S
	36	S	VS		S	S		S	M	S
	37	S	VS		S	S		S	M	S
Z	605	S	VS		S	S		S	M	S
	606	S	VS		S	S		S	M	S
	709	S	VS		S	S		S	M	S

—	— FLEMING —	— GIBBONEY —	— Mc ADAM —	— Mc DONNELL —	— SMITH —	— WHE
re n.	*Notes : None.*	*Notes : None.*	*Did not make this Inspection.*	*Notes : None.*	*Z 4, 5, 109 Sheets entirely Covered with Snow. No Record Obtained.*	*M M + 18, 19,*

PLATE III.
PROC. AM. SOC. TEST. MATS.
VOL. XIX, PART I.
REPORT OF COMMITTEE A-5:
CORROSION TESTS.

Cloudy; Light Snow.

Smith 8	Wheaton 9	Color: Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Adherence: Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9
S	M	M	D		D	L		M	L	M	T	T		T	T		T	T	T
S	M	M	D		D	L		M	L	M	T	T		T	T		T	T	T
S	M	M	D		D	L		M	L	M	T	T		T	T		T	T	T
S	M	M	D		D	L		M	L	M	T	T		T	T		T	T	T
S	M	M	D		D	L		M	L	M	T	T		T	T		T	T	T
S	M	M	D		D	L		M	L	M	T	T		T	T		T	T	T
S	M	M	D		D	L		M	L	M	T	T		T	T		T	T	T
S	M	M	D		D	L		M	L	M	T	T		T	T		T	T	T
S	M	M	D		D	L		M	L	M	T	T		T	T		T	T	T
C	M	M	M		M	M		L	L	M	T	T		M	T		L	T	T
C	M	M	M		M	M		L	L	M	T	T		M	T		L	T	T
C	M	M	M		M	M		L	L	M	T	T		M	T		L	T	T
M	M	M	D		D	M		M	M	M	T	T		T	T		T	T	T
M	M	M	D		D	M		M	M	M	T	T		T	T		T	T	T
M	M	M	D		D	M		M	M	M	T	T		T	T		T	T	T
M	M	M	D		D	M		M	M	M	T	T		T	T		T	T	T
M	M	M	D		D	M		M	M	M	T	T		T	T		T	T	T
M	M	M	D		D	M		M	M	M	T	T		T	T		T	T	T
M	M	M	D		D	M		M	M	M	T	T		T	T		T	T	T
M	M	M	D		D	M		M	M	M	T	T		T	T		T	T	T
M	M	M	D		D	M		M	M	M	T	T		T	T		T	T	T
M	M	M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	M	M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	M	M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	M	M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	M	M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	M	M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	M	M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	M	M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
M	S	D	D		D	D		D	M	M	T	T		T	T		T	T	T
M	S	D	D		D	D		D	M	M	T	T		T	T		T	T	T
M	S	D	D		D	D		D	M	M	T	T		T	T		T	T	T

ROW No. 9

Designation		Condition of Rust: Texture									Color									Adherence								
Mark	Sheet No.	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9
K	20	S	VS		S	S		S	S	S	D	D		D	M		D	M	M	T	T		T	T		T	T	T
	21	S	VS		S	S		S	S	S	D	D		D	M		D	M	M	T	T		T	T		T	T	T
	22	S	VS		S	S		S	S	S	D	D		D	M		D	M	M	T	T		T	T		T	T	T
	23	S	VS		S	S		S	S	S	D	D		D	M		D	M	M	T	T		T	T		T	T	T
	24	S	VS		S	S		S	S	S	D	D		D	M		D	M	M	T	T		T	T		T	T	T
	25	S	VS		S	S		S	S	S	D	D		D	M		D	M	M	T	T		T	T		T	T	T
	26	S	VS		S	S		S	S	S	D	D		D	M		D	M	M	T	T		T	T		T	T	T
	27	S	VS		S	S		S	S	S	D	D		D	M		D	M	M	T	T		T	T		T	T	T
	28	S	VS		S	S		S	S	S	D	D		D	M		D	M	M	T	T		T	T		T	T	T
	29	S	VS		S	S		S	S	S	D	D		D	M		D	M	M	T	T		T	T		T	T	T
	30	S	VS		S	S		S	S	S	D	D		D	M		D	M	M	T	T		T	T		T	T	T
	31	S	VS		S	S		S	S	S	D	D		D	M		D	M	M	T	T		T	T		T	T	T
	32	S	VS		S	S		S	S	S	D	D		D	M		D	M	M	T	T		T	T		T	T	T
M	18	M	M		M	M		M	M	M	M	D		D	M		M	M	M	T	T		T	T		T	T	T
	19	M	M		M	M		M	M	M	M	D		D	M		M	M	M	T	T		T	T		T	T	T
	20	M	M		M	M		M	M	M	M	D		D	M		M	M	M	T	T		T	T		T	T	T
	21	M	M		M	M		M	M	M	M	D		D	M		M	M	M	T	T		T	T		T	T	T
	22	M	M		M	M		M	M	M	M	D		D	M		M	M	M	T	T		T	T		T	T	T
	23	M	M		M	M		M	M	M	M	D		D	M		M	M	M	T	T		T	T		T	T	T
	24	M	M		M	M		M	M	M	M	D		D	M		M	M	M	T	T		T	T		T	T	T
	25	M	M		M	M		M	M	M	M	D		D	M		M	M	M	T	T		T	T		T	T	T
	26	M	M		M	M		M	M	M	M	D		D	M		M	M	M	T	T		T	T		T	T	T
	27	M	M		M	M		M	M	M	M	D		D	M		M	M	M	T	T		T	T		T	T	T
	28	M	M		M	M		M	M	M	M	D		D	M		M	M	M	T	T		T	T		T	T	T
S	18	C	C		C	C		C	C	C	L	L		L	L		L	L	M	L	L		L	T		L	T	T
	19	C	C		C	C		C	C	C	L	L		L	L		L	L	M	L	L		L	T		L	T	T
	20	C	C		C	C		C	C	C	L	L		L	L		L	L	M	L	L		L	T		L	T	T
	21	C	C		C	C		C	C	C	L	L		L	L		L	L	M	L	L		L	T		L	T	T
	22	C	C		C	C		C	C	C	L	L		L	L		L	L	M	L	L		L	T		L	T	T
	23	C	C		C	C		C	C	C	L	L		L	L		L	L	M	L	L		L	T		L	T	T
	24	C	C		C	C		C	C	C	L	L		L	L		L	L	M	L	L		L	T		L	T	T
	25	C	C		C	C		C	C	C	L	L		L	L		L	L	M	L	L		L	T		L	T	T
	26	C	C		C	C		C	C	C	L	L		L	L		L	L	M	L	L		L	T		L	T	T
	27	C	C		C	C		C	C	C	L	L		L	L		L	L	M	L	L		L	T		L	T	T
	28	C	C		C	C		C	C	C	L	L		L	L		L	L	M	L	L		L	T		L	T	T
T	18	S	S		S	M		S	M	M	D	D		D	D		D	M	M	T	T		T	T		T	T	T
	19	S	S		S	M		S	M	M	D	D		D	D		D	M	M	T	T		T	T		T	T	T
	20	S	S		S	M		S	M	M	D	D		D	D		D	M	M	T	T		T	T		T	T	T
	21	S	S		S	M		S	M	M	D	D		D	D		D	M	M	T	T		T	T		T	T	T
	22	S	S		S	M		S	M	M	D	D		D	D		D	M	M	T	T		T	T		T	T	T
	23	S	S		S	M		S	M	M	D	D		D	D		D	M	M	T	T		T	T		T	T	T
	24	S	S		S	M		S	M	M	D	D		D	D		D	M	M	T	T		T	T		T	T	T
	25	S	S		S	M		S	M	M	D	D		D	D		D	M	M	T	T		T	T		T	T	T
	26	S	S		S	M		S	M	M	D	D		D	D		D	M	M	T	T		T	T		T	T	T
	27	S	S		S	M		S	M	M	D	D		D	D		D	M	M	T	T		T	T		T	T	T
	28	S	S		S	M		S	M	M	D	D		D	D		D	M	M	T	T		T	T		T	T	T
U	18	C	S		M	M		M	C	C	M	D		M	M		D	M	M	L	T		M	T		T	T	T
	19	C	S		M	M		M	C	C	M	D		M	M		D	M	M	L	T		M	T		T	T	T
	20	C	S		M	M		M	C	C	M	D		M	M		D	M	M	L	T		M	T		T	T	T
	21	C	S		M	M		M	C	C	M	D		M	M		D	M	M	L	T		M	T		T	T	T

ROW No. 10

Designation		Condition of Rust: Texture									Color									Adherence								
Mark	Sheet No.	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	McAdam 6	McDonnell 7	Smith 8	Wheaton 9
U	22	M	S		M	C		S	M	S	M	D		M	M		D	M	M	T	T		M	T		T	T	T
	23	M	S		M	C		S	M	S	M	D		M	M		D	M	M	T	T		M	T		T	T	T
	24	M	S		M	C		S	M	S	M	D		M	M		D	M	M	T	T		M	T		T	T	T
	25	M	S		M	C		S	M	S	M	D		M	M		D	M	M	T	T		M	T		T	T	T
	26	M	S		M	C		S	M	S	M	D		M	M		D	M	M	T	T		M	T		T	T	T
	27	M	S		M	C		S	M	S	M	D		M	M		D	M	M	T	T		M	T		T	T	T
	28	M	S		M	C		S	M	S	M	D		M	M		D	M	M	T	T		M	T		T	T	T
V	18	S	S		S	M		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	19	S	S		S	M		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	20	S	S		S	M		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	21	S	S		S	M		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	22	S	S		S	M		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	23	S	S		S	M		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	24	S	S		S	M		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	25	S	S		S	M		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	26	S	S		S	M		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	27	S	S		S	M		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
	28	S	S		S	M		S	M	S	M	D		D	M		D	M	M	T	T		T	T		T	T	T
X	18	C	C		M	C		C	C	M	L	M		L	L		L	L	M	L	L		L	T		L	T	T
	19	C	C		M	C		C	C	M	L	M		L	L		L	L	M	L	L		L	T		L	T	T
	20	C	C		M	C		C	C	M	L	M		L	L		L	L	M	L	L		L	T		L	T	T
	21	C	C		M	C		C	C	M	L	M		L	L		L	L	M	L	L		L	T		L	T	T
	22	C	C		M	C		C	C	M	L	M		L	L		L	L	M	L	L		L	T		L	T	T
	23	C	C		M	C		C	C	M	L	M		L	L		L	L	M	L	L		L	T		L	T	T
	24	C	C		M	C		C	C	M	L	M		L	L		L	L	M	L	L		L	T		L	T	T
	25	C	C		M	C		C	C	M	L	M		L	L		L	L	M	L	L		L	T		L	T	T
	26	C	C		M	C		C	C	M	L	M		L	L		L	L	M	L	L		L	T		L	T	T
	27	C	C		M	C		C	C	M	L	M		L	L		L	L	M	L	L		L	T		L	T	T
	28	C	C		M	C		C	C	M	L	M		L	L		L	L	M	L	L		L	T		L	T	T
O	16	C	VC		M	VC		C	VC	M	L	L		M	D		L	L	M	L	L		L	L		L	L	T
	17	C	VC		M	VC		C	VC	M	L	L		M	D		L	L	M	L	L		L	L		L	L	T
	18	C	VC		M	VC		C	VC	M	L	L		M	D		L	L	M	L	L		L	L		L	L	T
	19	C	VC		M	VC		C	VC	M	L	L		M	D		L	L	M	L	L		L	L		L	L	T
	20	C	VC		M	VC		C	VC	M	L	L		M	D		L	L	M	L	L		L	L		L	L	T
	21	C	VC		M	VC		C	VC	M	L	L		M	D		L	L	M	L	L		L	L		L	L	T
	22	C	VC		M	VC		C	VC	M	L	L		M	D		L	L	M	L	L		L	L		L	L	T
	23	C	VC		M	VC		C	VC	M	L	L		M	D		L	L	M	L	L		L	L		L	L	T
	24	C	VC		M	VC		C	VC	M	L	L		M	D		L	L	M	L	L		L	L		L	L	T
Z	110	VS	VS		S	S		S	S	S	D	D		D	D		D	D	M	T	T		T	T		T	T	T
	207	VS	VS		S	S		S	S	S	D	D		D	D		D	D	M	T	T		T	T		T	T	T
	208	VS	VS		S	S		S	S	S	D	D		D	D		D	D	M	T	T		T	T		T	T	T
	306	VS	VS		S	S		S	S	S	D	D		D	D		D	D	M	T	T		T	T		T	T	T
	308	VS	VS		S	S		S	S	S	D	D		D	D		D	D	M	T	T		T	T		T	T	T
	420	M	C		M	C		C	C	M	L	L		M	L		L	M	M	L	L		L	L		L	T	T
	421	M	C		M	C		C	C	M	L	L		M	L		L	M	M	L	L		L	L		L	T	T
	506	S	VS		S	S		S	M	S	D	D		D	D		D	D	M	T	T		T	T		T	T	T
	508	S	VS		S	S		S	M	S	D	D		D	D		D	D	M	T	T		T	T		T	T	T

— WHEATON —

18, 19, 20, 22, Scale

James B. Gibboney

Chairman Inspection Committee

Date of Inspection.

ROW No. 1

Mark	Sheet No.	Texture 1 Aupperle	Texture 2 Buck	Texture 3 Cooper	Texture 4 Fleming	Texture 5 Gibboney	Texture 6 McAdam	Texture 7 McDonnell	Texture 8 Smith	Texture 9 Wheaton	Color 1 Aupperle	Color 2 Buck	Color 3 Cooper	Color 4 Fleming	Color 5 Gibboney	Color 6 McAdam	Color 7 McDonnell	Color 8 Smith	Color 9 Wheaton	Adherence 1 Aupperle	Adherence 2 Buck	Adherence 3 Cooper	Adherence 4 Fleming	Adherence 5 Gibboney	Adherence 6 McAdam	Adherence 7 McDonnell	Adherence 8 Smith	Adherence 9 Wheaton
AA	21	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	T	L
	22	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	T	L
	23	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	T	L
	24	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	T	L
BB	8	S	M	M	M	M		M	S	M	M	D	D	D	D		D	M	D	T	TL	T	T	T		T	T	T
	9	S	M	M	M	M		M	S	M	M	D	D	D	D		D	M	D	T	TL	T	T	T		T	T	T
	20	S	C	M	M	C		C	S	C	M	M	D	D	M		M	M	D	T	L	TL	T	L		L	T	T
	21	S	C	M	M	C		C	S	C	M	M	D	D	M		M	M	D	T	L	TL	T	L		L	T	T
CC	15	C	C	M	M	M		M	M	C	M	M	D	D	M		M	M	D	L	L	T	T	T		L	T	T
	16	C	C	M	M	M		M	M	C	M	M	D	D	M		M	M	D	L	L	T	T	T		L	T	T
	17	C	C	M	M	M		M	M	C	M	M	D	D	M		M	M	D	L	L	T	T	T		L	T	T
	18	C	C	M	M	M		M	M	C	M	M	D	D	M		M	M	D	L	L	T	T	T		L	T	T
DD	25	VC	VC	VC	VC	C		C	C	VC	L	M	L	L	M		L	L	M	L	L	L	L	L		L	L	T
	26	VC	VC	VC	VC	C		C	C	VC	L	M	L	L	M		L	L	M	L	L	L	L	L		L	L	T
	27	VC	VC	VC	VC	C		C	C	VC	L	M	L	L	M		L	L	M	L	L	L	L	L		L	L	T
	28	VC	VC	VC	VC	C		C	C	VC	L	M	L	L	M		L	L	M	L	L	L	L	L		L	L	T
EE✱	13	M	M	S	S	S		S	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	14	M	M	S	S	S		S	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	15	M	M	S	S	S		S	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	16	M	M	S	S	S		S	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
HH	19	S	S	S	S	S		S	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	20	S	S	S	S	S		S	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	21	S	S	S	S	S		S	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	22	S	S	S	S	S		S	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
II	30	VS	VS	S	S	VS		VS	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	21	VS	VS	S	S	VS		VS	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	22	VS	VS	S	S	VS		VS	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	23	VS	VS	S	S	VS		VS	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
KK	6	VS	VS	S	S	S		VS	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	7	VS	VS	S	S	S		VS	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	8	VS	VS	S	S	S		VS	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	27	VS	VS	S	S	S		VS	VS	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
MM✱	29	C	M	C	M	M		M	M	C	D	D	M	M	M		M	M	D	T	TL	TL	T	T		L	T	T
	30	C	M	C	M	M		M	M	C	D	D	M	M	M		M	M	D	T	TL	TL	T	T		L	T	T
	31	C	M	C	M	M		M	M	C	D	D	M	M	M		M	M	D	T	TL	TL	T	T		L	T	T
	32	C	M	C	M	M		M	M	C	D	D	M	M	M		M	M	D	T	TL	TL	T	T		L	T	T
SS	29	VC	VC	VC	VC	VC		VC	VC	VC	M	L	L	L	L		L	L	M	L	L	L	L	L		L	T	T
	30	VC	VC	VC	VC	VC		VC	VC	VC	M	L	L	L	L		L	L	M	L	L	L	L	L		L	T	T
	31	VC	VC	VC	VC	VC		VC	VC	VC	M	L	L	L	L		L	L	M	L	L	L	L	L		L	T	T
	32	VC	VC	VC	VC	VC		VC	VC	VC	M	L	L	L	L		L	L	M	L	L	L	L	L		L	T	T
TT	29	S	S	VS	S	S		S	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	30	S	S	VS	S	S		S	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	31	S	S	VS	S	S		S	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	32	S	S	VS	S	S		S	VS	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
UU	29	S	S	S	S	S		S		S	D	D	D	D	M		D		D	T	T	T	T	T		T		T
	30	S	S	S	S	S		S		S	D	D	D	D	M		D		D	T	T	T	T	T		T		T
	31	S	S	S	S	S		S		S	D	D	D	D	M		D		D	T	T	T	T	T		T		T
	32	S	S	S	S	S		S		S	D	D	D	D	M		D		D	T	T	T	T	T		T		T
VV	39	S	S	S	S	S		S		S	D	D	D	D	M		D		D	T	T	T	T	T		T		T
	40	S	S	S	S	S		S		S	D	D	D	D	M		D		D	T	T	T	T	T		T		T
	41	S	S	S	S	S		S		S	D	D	D	D	M		D		D	T	T	T	T	T		T		T
	42	S	S	S	S	S		S		S	D	D	D	D	M		D		D	T	T	T	T	T		T		T
XX	29	VC	VC	VC	VC	VC		VC	C	VC	M	L	L	L	L		L	L	M	L	L	L	L	L		L	T	L
	30	VC	VC	VC	VC	VC		VC	C	VC	M	L	L	L	L		L	L	M	L	L	L	L	L		L	T	L
	31	VC	VC	VC	VC	VC		VC	C	VC	M	L	L	L	L		L	L	M	L	L	L	L	L		L	T	L
	32	VC	VC	VC	VC	VC		VC	C	VC	M	L	L	L	L		L	L	M	L	L	L	L	L		L	T	L
OO	25	C	C	C	C	C		C	M	C	M	L	L	L	M		L	L	D	L	L	TL	L	L		L	T	T
	26	C	C	C	C	C		C	M	C	M	L	L	L	M		L	L	D	L	L	TL	L	L		L	T	T
	27	C	C	C	C	C		C	M	C	M	L	L	L	M		L	L	D	L	L	TL	L	L		L	T	T
	28	C	C	C	C	C		C	M	C	M	L	L	L	M		L	L	D	L	L	TL	L	L		L	T	T
CCC	1	M	S	S	S	M		M		M	D	D	D	D	D		M		D	T	T	T	T	T		T		T
	2	M	S	S	S	M		M		M	D	D	D	D	D		M		D	T	T	T	T	T		T		T
	3	M	S	S	S	M		M		M	D	D	D	D	D		M		D	T	T	T	T	T		T		T
	4	M	S	S	S	M		M		M	D	D	D	D	D		M		D	T	T	T	T	T		T		T
ZZ	9	VC	VC	VC	VC	C		VC	VC	C	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	TL
	10	VC	VC	VC	VC	C		VC	VC	C	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	TL
	11	VC	VC	VC	VC	C		VC	VC	C	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	TL
	107	S	S	S	S	S		M	VS	VS	D	M	D	D	M		D	M	D	T	T	T	T	T		T	T	T
	310	VS	VS	VS	S	VS		S	VS	VS	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	311	VS	VS	VS	S	VS		S	VS	VS	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T

✱ Open Annealed.

ROW No. 2

Mark	Sheet No.	Texture 1 Aupperle	Texture 2 Buck	Texture 3 Cooper	Texture 4 Fleming	Texture 5 Gibboney	Texture 6 McAdam	Texture 7 McDonnell	Texture 8 Smith	Texture 9 Wheaton	Color 1 Aupperle	Color 2 Buck	Color 3 Cooper	Color 4 Fleming	Color 5 Gibboney	Color 6 McAdam	Color 7 McDonnell	Color 8 Smith	Color 9 Wheaton	Adherence 1 Aupperle	Adherence 2 Buck	Adherence 3 Cooper	Adherence 4 Fleming	Adherence 5 Gibboney	Adherence 6 McAdam	Adherence 7 McDonnell	Adherence 8 Smith	Adherence 9 Wheaton
A	31	VC	VC	VC	VC	VC		VC	C	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	32	VC	VC	VC	VC	VC		VC	C	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	33	VC	VC	VC	VC	VC		VC	C	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	34	VC	VC	VC	VC	VC		VC	C	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
B	17	M	M	C	S	M		M	S	M	D	D	D	D	D		D	M	D	T	TL	TL	T	T		T	T	T
	18	M	M	C	S	M		M	S	M	D	D	D	D	D		D	M	D	T	TL	TL	T	T		T	T	T
	19	M	M	C	S	M		M	S	M	D	D	D	D	D		D	M	D	T	TL	TL	T	T		T	T	T
	20	M	M	C	S	M		M	S	M	D	D	D	D	D		D	M	D	T	TL	TL	T	T		T	T	T
C	11	M	M	C	S	M		M	S	M	D	M	L	D	D		D	M	D	T	TL	TL	T	T		T	T	T
	12	M	M	C	S	M		M	S	M	D	M	L	D	D		D	M	D	T	TL	TL	T	T		T	T	T
	13	M	M	C	S	M		M	S	M	D	M	L	D	D		D	M	D	T	TL	TL	T	T		T	T	T
	14	M	M	C	S	M		M	S	M	D	M	L	D	D		D	M	D	T	TL	TL	T	T		T	T	T
D	30	VC	VC	VC	VC	VC		VC	C	VC	L	L	D	L	L		L	L	M	L	L	L	L	L		L	T	L
	31	VC	VC	VC	VC	VC		VC	C	VC	L	L	D	L	L		L	L	M	L	L	L	L	L		L	T	L
	33	VC	VC	VC	VC	VC		VC	C	VC	L	L	D	L	L		L	L	M	L	L	L	L	L		L	T	L
	34	VC	VC	VC	VC	VC		VC	C	VC	L	L	D	L	L		L	L	M	L	L	L	L	L		L	T	L
E	25	S	M	M	S	C		M	M	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	26	S	M	M	S	C		M	M	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	27	S	M	M	S	C		M	M	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	28	S	M	M	S	C		M	M	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
H	38	VS	S	S	S	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	40	VS	S	S	S	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	41	VS	S	S	S	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	42	VS	S	S	S	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
I	38	VS	VS	S	S	VS		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	39	VS	VS	S	S	VS		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	40	VS	VS	S	S	VS		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	41	VS	VS	S	S	VS		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
K	33	VS	VS	S	S	VS		S	S	S	D	D	D	D	D		M	D	D	T	T	T	T	T		T	T	T
	34	VS	VS	S	S	VS		S	S	S	D	D	D	D	D		M	D	D	T	T	T	T	T		T	T	T
	35	VS	VS	S	S	VS		S	S	S	D	D	D	D	D		M	D	D	T	T	T	T	T		T	T	T
	36	VS	VS	S	S	VS		S	S	S	D	D	D	D	D		M	D	D	T	T	T	T	T		T	T	T
M	29	S	M	S	M	M		M	S	M	D	D	D	D	D		M	D	D	T	T	T	T	T		T	T	T
	30	S	M	S	M	M		M	S	M	D	D	D	D	D		M	D	D	T	T	T	T	T		T	T	T
	31	S	M	S	M	M		M	S	M	D	D	D	D	D		M	D	D	T	T	T	T	T		T	T	T
	32	S	M	S	M	M		M	S	M	D	D	D	D	D		M	D	D	T	T	T	T	T		T	T	T
S	29	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	30	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	31	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	32	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
T	29	VS	S	M	S	VS		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	30	VS	S	M	S	VS		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	31	VS	S	M	S	VS		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	32	VS	S	M	S	VS		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
U	29	VS	S	M	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	30	VS	S	M	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	31	VS	S	M	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	32	VS	S	M	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
V	29	M	S	M	S	S		S	S	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	30	M	S	M	S	S		S	S	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	31	M	S	M	S	S		S	S	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	32	M	S	M	S	S		S	S	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
X	29	VC	VC	VC	VC	VC		VC	C	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	T	L
	30	VC	VC	VC	VC	VC		VC	C	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	T	L
	31	VC	VC	VC	VC	VC		VC	C	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	T	L
	32	VC	VC	VC	VC	VC		VC	C	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	T	L
O	25	VC			VC	VC				VC	L			L	L				D	L			L	L				L
	26	VC			VC	VC				VC	L			L	L				D	L			L	L				L
	27	VC			VC	VC				VC	L			L	L				D	L			L	L				L
	28	VC			VC	VC				VC	L			L	L				D	L			L	L				L
Z	6	VC	VC	VC	VC	VC		VC	C	C	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	7	VC	VC	VC	VC	VC		VC	C	C	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	11	VC	VC	VC	VC	VC		VC	C	C	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	111	VS	S	S	VS	VS		S	S	M	D	D	D	D	D		D	D	M	T	T	T	T	T		T	T	T
	112	VS	S	S	VS	VS		S	S	M	D	D	D	D	D		D	D	M	T	T	T	T	T		T	T	T
	113	VS	S	S	VS	VS		S	S	M	D	D	D	D	D		D	D	M	T	T	T	T	T		T	T	T
	[illegible]	VS	VS	VS	VS	VS		S	S	M	D	D	D	D	D		D	D	M	T	T	T	T	T		T	T	T
	213	VS	VS	VS	VS	VS		S	S	M	D	D	D	D	D		D	D	M	T	T	T	T	T		T	T	T
	214	VS	VS	VS	VS	VS		S	S	M	D	D	D	D	D		D	D	M	T	T	T	T	T		T	T	T
	310	VS	VS	VS	VS	VS		S	S	M	D	D	D	D	D		D	D	M	T	T	T	T	T		T	T	T

ROW No. 3

Mark	Sheet No.	Texture 1 Aupperle	Texture 2 Buck	Texture 3 Cooper	Texture 4 Fleming	Texture 5 Gibboney	Texture 6 McAdam	Texture 7 McDonnell	Texture 8 Smith	Texture 9 Wheaton	Color 1 Aupperle	Color 2 Buck	Color 3 Cooper	Color 4 Fleming
AA	25	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L
	26	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L
	27	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L
	28	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L
	29	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L
	30	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L
AA✱	50	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L
	51	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L
	52	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L
	53	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L
	54	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L
	55	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L
	56	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L
BB	22	C	C	C	C	C		M	M	C	L	M	L	M
	23	C	C	C	C	C		M	M	C	L	M	L	M
	24	C	C	C	C	C		M	M	C	L	M	L	M
	40	M	M	M	M	M		M	S	M	M	D	M	D
	41	M	M	M	M	M		M	S	M	M	D	M	D
BB✱	33	M	M	M	M	M		M	S	M	M	M	M	D
	34	M	M	M	M	M		M	S	M	M	M	M	D
	35	M	M	M	M	M		M	S	M	M	M	M	D
	36	M	M	M	M	M		M	S	M	M	M	M	D
	50	M	M	M	M	M		M	S	M	M	M	M	D
	51	M	M	M	M	M		M	S	M	M	M	M	D
	52	M	M	M	M	M		M	S	M	M	M	M	D
	53	M	M	M	M	M		M	S	M	M	M	M	D
CC	7	C	M	M	M	C		M	M	M	M	M	M	D
	19	C	C	C	M	C		C	C	C	M	L	L	D
CC✱	31	C	C	C	M	C		C	C	C	M	L	L	D
	32	C	C	C	M	C		C	C	C	M	L	L	D
	33	C	C	C	M	C		C	C	C	M	L	L	D
	34	C	C	C	M	C		C	C	C	M	L	L	D
	35	C	C	C	M	C		C	C	C	M	L	L	D
	36	C	C	C	M	C		C	C	C	M	L	L	D
DD	8	C	VC	VC	VC	VC		C	C	VC	M	L	L	L
	9	C	VC	VC	VC	VC		C	C	VC	M	L	L	L
	10	C	VC	VC	VC	VC		C	C	VC	M	L	L	L
	29	C	VC	VC	VC	VC		C	C	VC	M	L	L	L
	30	C	VC	VC	VC	VC		C	C	VC	M	L	L	L
	31	C	VC	VC	VC	VC		C	C	VC	M	L	L	L
DD✱	47	C	VC	VC	VC	VC		C	C	VC	M	L	L	L
	48	C	VC	VC	VC	VC		C	C	VC	M	L	L	L
	49	C	VC	VC	VC	VC		C	C	VC	M	L	L	L
	54	C	VC	VC	VC	VC		C	C	C	M	L	L	L
	55	C	VC	VC	VC	VC		C	C	C	M	L	L	L
	56	C	VC	VC	VC	VC		C	C	C	M	L	L	L
	57	C	VC	VC	VC	VC		C	C	C	M	L	L	L
	58	C	VC	VC	VC	VC		C	C	C	M	L	L	L
EE†	17	S	S	M	S	S		S	S	M	M	D	D	D
	18	S	S	M	S	S		S	S	M	M	D	D	D
EE✱†	31	S	S	M	S	S		S	S	M	M	D	D	D
	32	S	S	M	S	S		S	S	M	M	D	D	D
	33	S	S	M	S	S		S	S	M	M	D	D	D
	34	S	S	M	S	S		S	S	M	M	D	D	D
	35	S	S	M	S	S		S	S	M	M	D	D	D
	36	S	S	M	S	S		S	S	M	M	D	D	D
HH	23	S	S	M	S	S		S	VS	M	M	D	D	D
	24	S	S	M	S	S		S	VS	M	M	D	D	D
	25	S	S	M	S	S		S	VS	M	M	D	D	D
	26	S	S	M	S	S		S	VS	M	M	D	D	D
HH✱	43	S	S	M	S	S		S	S	M	M	D	D	D
	44	S	S	M	S	S		S	S	M	M	D	D	D
	45	S	S	M	S	S		S	S	M	M	D	D	D
	46	S	S	M	S	S		S	S	M	M	D	D	D
	47	S	S	M	S	S		S	S	M	M	D	D	D
	48	S	S	M	S	S		S	S	M	M	D	D	D
	49	S	S	M	S	S		S	S	M	M	D	D	D
II	24	S	VS	S	S	S		VS	VS	M	M	D	D	D
	25	S	VS	S	S	S		VS	VS	M	M	D	D	D
	27	S	VS	S	S	S		VS	VS	M	M	D	D	D
	28	S	VS	S	S	S		VS	VS	M	M	D	D	D
	29	S	VS	S	S	S		VS	VS	M	M	D	D	D

✱ Sand Blasted.

† Open Annealed.

CONDITION OF RUST

Texture	Color	Adherence
VS—Very Smooth	L—Light	T—Tight
S—Smooth	M—Medium	L—Loose
M—Medium	D—Dark	
C—Coarse		
VC—Very Coarse		

— INSPECTION COMMITTEE —

J. H. Gibboney, Chairman — Norfolk & Western Railroad.
J. A. Aupperle, — American Rolling Mill Co.
D. M. Buck — American Sheet & Tin Plate Co.
W. A. Cooper — Alan Wood Iron & Steel Co.
W. R. Fleming — The Andrews Steel Co.
D. J. McAdam, Jr. — U. S. Navy, Bureau Steam Engineering.
M. E. McDonnell — Pennsylvania Railroad.
H. E. Smith — U. S. Railroad Administration.
F. B. Wheaton — U. S. Army, Quartermaster's Corps

— AUPPERLE —

Sheets	CC	17	Accidental Crack.	Sheets	A 3
"	A	31 to 34 incl	Failure, 1 Foot	"	B 3
"	D	30	" , 1 "	"	D 3
"	D	31 to 33 "	" .	"	D 3
"	D	34	" , 2 Feet.	"	D 3
"	S	29 to 32 "	" , 2 " .	"	D 3
"	X	29	" , 8 inches.	"	D 4
"	X	30	" , 6 " .	"	F 2
"	X	32	" , 12 " .	"	E 3
"	O	25 to 28 "	" , all Gone.	"	F 3
"	Z	6, 7, 11	" , 18 Inches.	"	E 3
"	AA	25 to 30 "	" , Bad Ends	"	F 3
"	AA✱	50 to 56 "	" , " " .	"	I 4

Table IV.—Results of Inspection of Corrosion Test Shee

AMERICAN SOCIETY FOR TESTIN
COMMITTEE A-5 ON CORROSION OF IRON
TESTS OF UNCOATED SHEETS
PITTSBURGH, PA.
EXPOSED DECEMBER 12, 1916

on. *April 1, 1919.*

Color									Adherence								
1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton
L	L	L	L	L		L	M	D	L	L	L	L	L		L	L	L
L	L	L	L	L		L	M	D	L	L	L	L	L		L	L	L
L	L	L	L	L		L	M	D	L	L	L	L	L		L	L	L
L	L	L	L	L		L	M	D	L	L	L	L	L		L	L	L
L	L	L	L	L		L	M	D	L	L	L	L	L		L	L	L
L	L	L	L	L		L	M	D	L	L	L	L	L		L	L	L
L	L	L	L	L		L	M	D	L	L	L	L	L		L	L	L
L	L	L	L	L		L	M	D	L	L	L	L	L		L	L	L
L	L	L	L	L		L	M	D	L	L	L	L	L		L	L	L
L	L	L	L	L		L	M	D	L	L	L	L	L		L	L	L
L	L	L	L	L		L	M	D	L	L	L	L	L		L	L	L
L	L	L	L	L		L	M	D	L	L	L	L	L		L	L	L
L	L	L	L	L		L	M	D	L	L	L	L	L		L	L	L
L	M	L	M	D		M	L	M	L	L	L	M	L		T	L	T
L	M	L	M	D		M	L	M	L	L	L	M	L		T	L	T
L	M	L	M	D		M	L	M	L	L	L	M	L		T	L	T
M	D	M	D	M		M	M	D	L	TL	TL	T	T		T	T	T
M	D	M	D	M		M	M	D	L	TL	TL	T	T		T	T	T
M	M	M	D	D		M	M	D	L	TL	TL	T	T		T	T	T
M	M	M	D	D		M	M	D	L	TL	TL	T	T		T	T	T
M	M	M	D	D		M	M	D	L	TL	TL	T	T		T	T	T
M	M	M	D	D		M	M	D	L	TL	TL	T	T		T	T	T
M	M	M	D	D		M	M	D	L	TL	TL	T	T		T	T	T
M	M	M	D	D		M	M	D	L	TL	TL	T	T		T	T	T
M	M	M	D	D		M	M	D	L	TL	TL	T	T		T	T	T
M	M	M	D	D		M	M	D	L	TL	TL	T	T		T	T	T
M	M	M	D	M		M	M	D	L	L	L	T	T		L	T	T
M	L	L	D	M		M	L	D	L	L	L	T	T		L	L	T
M	L	L	D	M		M	L	D	L	L	L	T	T		L	L	T
M	L	L	D	M		M	L	D	L	L	L	T	T		L	L	T
M	L	L	D	M		M	L	D	L	L	L	T	T		L	L	T
M	L	L	D	M		M	L	D	L	L	L	T	T		L	L	T
M	L	L	D	M		M	L	D	L	L	L	T	T		L	L	T
M	L	L	D	M		M	L	D	L	L	L	T	T		L	L	T
M	L	L	L	M		L	L	M	L	L	L	L	L		L	L	T
M	L	L	L	M		L	L	M	L	L	L	L	L		L	L	T
M	L	L	L	M		L	L	M	L	L	L	L	L		L	L	T
M	L	L	L	M		L	L	M	L	L	L	L	L		L	L	T
M	L	L	L	M		L	L	M	L	L	L	L	L		L	L	T
M	L	L	L	M		L	L	M	L	L	L	L	L		L	L	T
M	L	L	L	M		L	L	M	L	L	L	L	L		L	L	T
M	L	L	L	M		L	L	M	L	L	L	L	L		L	L	T
M	L	L	L	M		L	L	M	L	L	L	L	L		L	L	T
M	L	L	L	M		L	L	M	L	L	L	L	L		L	L	T
M	L	L	L	M		L	L	M	L	L	L	L	L		L	L	T
M	L	L	L	M		L	L	M	L	L	L	L	L		L	L	T
M	L	L	L	M		L	L	M	L	L	L	L	L		L	L	T
M	L	L	L	M		L	L	M	L	L	L	L	L		L	L	T.
M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
M	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
M	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T

ROW No. 4

Designation		Condition of Rust																										
Mark	Sheet No.	Texture									Color									Adherence								
		1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton
II*	48	VS	VS	S	S	S		S	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	49	VS	VS	S	S	S		S	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	50	VS	VS	S	S	S		S	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	51	VS	VS	S	S	S		S	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	52	VS	VS	S	S	S		S	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	53	VS	VS	S	S	S		S	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	54	VS	VS	S	S	S		S	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	55	VS	VS	S	S	S		S	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	56	VS	VS	S	S	S		S	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
KK	28	VS	VS	S	S	S		S	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	29	VS	VS	S	S	S		S	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	30	VS	VS	S	S	S		S	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	31	VS	VS	S	S	S		S	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	32	VS	VS	S	S	S		S	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	33	VS	VS	S	S	S		S	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	34	VS	VS	S	S	S		S	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
KK*	51	VS	VS	S	S	S		S	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	52	VS	VS	S	S	S		S	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	53	VS	VS	S	S	S		S	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	54	VS	VS	S	S	S		S	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	55	VS	VS	S	S	S		S	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	56	VS	VS	S	S	S		S	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	57	VS	VS	S	S	S		S	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	58	VS	VS	S	S	S		S	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
MM†	33	C	M	C	C	M		M	M	C	M	M	M	M	D		C	M	M	L	TL	TL	M	L		L	L	T
	34	C	M	C	C	M		M	M	C	M	M	M	M	D		C	M	M	L	TL	TL	M	L		L	L	T
	35	C	M	C	C	M		M	M	C	M	M	M	M	D		C	M	M	L	TL	TL	M	L		L	L	T
	36	C	M	C	C	M		M	M	C	M	M	M	M	D		C	M	M	L	TL	TL	M	L		L	L	T
	37	C	M	C	C	M		M	M	C	M	M	M	M	D		C	M	M	L	TL	TL	M	L		L	L	T
	38	C	M	C	C	M		M	M	C	M	M	M	M	D		C	M	M	L	TL	TL	M	L		L	L	T
	39	C	M	C	C	M		M	M	C	M	M	M	M	D		C	M	M	L	TL	TL	M	L		L	L	T
	40	C	M	C	C	M		M	M	C	M	M	M	M	D		C	M	M	L	TL	TL	M	L		L	L	T
	41	C	M	C	C	M		M	M	C	M	M	M	M	D		C	M	M	L	TL	TL	M	L		L	L	T
	42	C	M	C	C	M		M	M	C	M	M	M	M	D		C	M	M	L	TL	TL	M	L		L	L	T
SS	33	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	34	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	35	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	36	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	37	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	38	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	39	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	40	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	41	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	42	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
TT	33	S	S	S	S	S		S	VS	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	34	S	S	S	S	S		S	VS	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	35	S	S	S	S	S		S	VS	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	36	S	S	S	S	S		S	VS	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	37	S	S	S	S	S		S	VS	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	38	S	S	S	S	S		S	VS	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	39	S	S	S	S	S		S	VS	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	40	S	S	S	S	S		S	VS	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	41	S	S	S	S	S		S	VS	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	42	S	S	S	S	S		S	VS	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
UU	33	S	S	S	S	S		S	S	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	34	S	S	S	S	S		S	S	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	35	S	S	S	S	S		S	S	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	36	S	S	S	S	S		S	S	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	37	S	S	S	S	S		S	S	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	38	S	S	S	S	S		S	S	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	39	S	S	S	S	S		S	S	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	40	S	S	S	S	S		S	S	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	41	S	S	S	S	S		S	S	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	42	S	S	S	S	S		S	S	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
VV	43	M	S	S	S	S		S	VS	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	44	M	S	S	S	S		S	VS	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	45	M	S	S	S	S		S	VS	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	46	M	S	S	S	S		S	VS	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	47	M	S	S	S	S		S	VS	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	48	M	S	S	S	S		S	VS	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	49	M	S	S	S	S		S	VS	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	50	M	S	S	S	S		S	VS	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	51	M	S	S	S	S		S	VS	M	M	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T

ROW No. 5

Designation		Condition of Rust																										
Mark	Sheet No.	Texture									Color									Adherence								
		1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 McAdam	7 McDonnell	8 Smith	9 Wheaton
XX	33	VC	C	C	VC	C		VC	C	C	L	L	L	L	M		L	L	D	L	L	L	L	L		L	L	T
	34	VC	C	C	VC	C		VC	C	C	L	L	L	L	M		L	L	D	L	L	L	L	L		L	L	T
	35	VC	C	C	VC	C		VC	C	C	L	L	L	L	M		L	L	D	L	L	L	L	L		L	L	T
	36	VC	C	C	VC	C		VC	C	C	L	L	L	L	M		L	L	D	L	L	L	L	L		L	L	T
	37	VC	C	C	VC	C		VC	C	C	L	L	L	L	M		L	L	D	L	L	L	L	L		L	L	T
	38	VC	C	C	VC	C		VC	C	C	L	L	L	L	M		L	L	D	L	L	L	L	L		L	L	T
	39	VC	C	C	VC	C		VC	C	C	L	L	L	L	M		L	L	D	L	L	L	L	L		L	L	T
	40	VC	C	C	VC	C		VC	C	C	L	L	L	L	M		L	L	D	L	L	L	L	L		L	L	T
	41	VC	C	C	VC	C		VC	C	C	L	L	L	L	M		L	L	D	L	L	L	L	L		L	L	T
	42	VC	C	C	VC	C		VC	C	C	L	L	L	L	M		L	L	D	L	L	L	L	L		L	L	T
ZZ	208	S	VS	S	S	VS		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	209	S	VS	S	S	VS		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	213	S	VS	S	S	VS		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	314	S	VS	S	S	VS		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	426	VC	C	C	VC	C		C	C	C	L	L	L	L	M		L	L	M	L	L	L	L	L		L	L	T
	427	VC	C	C	VC	C		C	C	C	L	L	L	L	M		L	L	M	L	L	L	L	L		L	L	T
	507	M	VS	S	S	VS		S	S	M	M	D	D	D	D		D	M	D	L	T	T	T	T		T	T	T
	510	M	VS	S	S	VS		S	S	M	M	D	D	D	D		D	M	D	L	T	T	T	T		T	T	T
	509	M	VS	S	S	VS		S	S	M	M	D	D	D	D		D	M	D	L	T	T	T	T		T	T	T
	612	M	VS	VS	S	VS		S	VS	S	D	D	D	D	D		D	D	D	L	T	T	T	T		T	T	T
	614	M	VS	VS	S	VS		S	VS	S	D	D	D	D	D		D	D	D	L	T	T	T	T		T	T	T
	615	M	VS	VS	S	VS		S	VS	S	D	D	D	D	D		D	D	D	L	T	T	T	T		T	T	T
	714	M	VS	VS	S	VS		S	VS	S	D	D	D	D	D		D	D	D	L	T	T	T	T		T	T	T
	715	M	VS	VS	S	VS		S	VS	S	D	D	D	D	D		D	D	D	L	T	T	T	T		T	T	T
OO	29	C	VC	C	VC	C		VC	C	VC	L	L	L	L	M		L	L	M	L	L	L	L	L		L	L	L
	30	C	VC	C	VC	C		VC	C	VC	L	L	L	L	M		L	L	M	L	L	L	L	L		L	L	L
	31	C	VC	C	VC	C		VC	C	VC	L	L	L	L	M		L	L	M	L	L	L	L	L		L	L	L
	32	C	VC	C	VC	C		VC	C	VC	L	L	L	L	M		L	L	M	L	L	L	L	L		L	L	L
	33	C	VC	C	VC	C		VC	C	VC	L	L	L	L	M		L	L	M	L	L	L	L	L		L	L	L
	34	C	VC	C	VC	C		VC	C	VC	L	L	L	L	M		L	L	M	L	L	L	L	L		L	L	L
	35	C	VC	C	VC	C		VC	C	VC	L	L	L	L	M		L	L	M	L	L	L	L	L		L	L	L
	36	C	VC	C	VC	C		VC	C	VC	L	L	L	L	M		L	L	M	L	L	L	L	L		L	L	L
OOO	5	M	M	M	M	M		M	M	M	M	M	M	D	D		D	M	D	L	T	T	T	T		T	T	T
	6	M	M	M	M	M		M	M	M	M	M	M	D	D		D	M	D	L	T	T	T	T		T	T	T
	7	M	M	M	M	M		M	M	M	M	M	M	D	D		D	M	D	L	T	T	T	T		T	T	T
	8	M	M	M	M	M		M	M	M	M	M	M	D	D		D	M	D	L	T	T	T	T		T	T	T
	9	M	M	M	M	M		M	M	M	M	M	M	D	D		D	M	D	L	T	T	T	T		T	T	T
	10	M	M	M	M	M		M	M	M	M	M	M	D	D		D	M	D	L	T	T	T	T		T	T	T
	11	M	M	M	M	M		M	M	M	M	M	M	D	D		D	M	D	L	T	T	T	T		T	T	T
	12	M	M	M	M	M		M	M	M	M	M	M	D	D		D	M	D	L	T	T	T	T		T	T	T
A	35	VC	VC	VC	VC	VC		VC		VC	L	L	L	L	L		L		M	L	L	L	L	L		L		L
	36	VC	VC	VC	VC	VC		VC		VC	L	L	L	L	L		L		M	L	L	L	L	L		L		L
	37	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	38	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	39	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	40	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	41	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	42	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	43	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	44	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	45	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	46	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	47	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
B	21	M	M	S	M	M		M	VS	M	M	M	D	M	D		D	M	D	T	TL	T	M	T		T	T	T
	22	M	M	S	M	M		M	VS	M	M	M	D	M	D		D	M	D	T	TL	T	M	T		T	T	T
	23	M	M	S	M	M		M	VS	M	M	M	D	M	D		D	M	D	T	TL	T	M	T		T	T	T
	34	M	S	S	S	M		M	S	M	M	M	D	M	D		D	M	D	T	TL	T	M	T		T	T	T
	35	M	M	S	M	M		C	S	C	M	M	D	L	D		M	M	M	T	TL	T	L	T		L	T	T
	36	M	M	S	M	M		C	S	C	M	M	D	L	D		M	M	M	T	TL	T	L	T		L	T	T
	37	M	M	S	M	M		C	S	C	M	M	D	L	D		M	M	M	T	TL	T	L	T		L	T	T
	38	M	M	S	M	M		C	S	C	M	M	D	L	D		M	M	M	T	TL	T	L	T		L	T	T
	39	M	M	S	S	M		S	S	M	M	M	D	M	D		D	M	D	T	TL	T	M	T		T	T	T
C	20	M	M	S	M	M		M	S	M	M	M	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	21	M	M	S	M	M		M	S	M	M	M	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	22	M	M	S	M	M		M	S	M	M	M	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	32	M	M	S	M	M		M	S	M	M	M	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	33	M	M	S	M	M		M	S	M	M	M	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	34	M	M	S	M	M		M	S	M	M	M	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	35	M	M	S	M	M		M	S	M	M	M	M	D	D		D	M	D	T	T	T	T	T		T	T	T

ROW No. 6

Designation					
Mark	Sheet No.	1 Aupperle	2 Buck	3 Cooper	4 Fleming
D	35	VC	VC	C	VC
	36	VC	VC	C	VC
	38	VC	VC	C	VC
	39	VC	VC	C	VC
	40	VC	VC	C	VC
E	29	S	S	M	M
	30	S	S	M	M
	31	S	S	M	M
	32	S	S	M	M
	33	S	S	M	M
	34	S	S	M	M
	35	S	S	M	M
	36	S	S	M	M
H	43	S	S	S	M
	45	S	S	S	M
	47	S	S	S	M
	49	S	S	S	M
	50	S	S	S	M
	53	S	S	S	M
	54	S	S	S	M
	55	S	S	S	M
I	42	S	VS	S	S
	43	S	VS	S	S
	44	S	VS	S	S
	45	S	VS	S	S
	46	S	VS	S	S
	47	S	VS	S	S
	48	S	VS	S	S
	49	S	VS	S	S
	50	S	VS	S	S
	51	S	VS	S	S
	52	S	VS	S	S
	53	S	VS	S	S
	54	S	VS	S	S
	55	S	VS	S	S
K	37	S	VS	S	S
	38	S	VS	S	S
	39	S	VS	S	S
	40	S	VS	S	S
	41	S	VS	S	S
	42	S	VS	S	S
	43	S	VS	S	S
	44	S	VS	S	S
	45	S	VS	S	S
	46	S	VS	S	S
	47	S	VS	S	S
	48	S	VS	S	S
M	33	C	M	M	S
	34	C	M	M	S
	35	C	M	M	S
	36	C	M	M	S
	37	C	M	M	S
	38	C	M	M	S
	39	C	M	M	S
	40	C	M	M	S
	41	C	M	M	S
	42	C		M	S
S	33	VC	VC	VC	VC
	34	VC	VC	VC	VC
	35	VC	VC	VC	VC
	36	VC	VC	VC	VC
	37	VC	VC	VC	VC
	38	VC	VC	VC	VC
	39	VC	VC	VC	VC
	40	VC	VC	VC	VC
	41	VC	VC	VC	VC
	42	VC	VC	VC	VC

* Sand Blasted.
† Open Annealed.

Sheets A 3[illegible] to 47 incl. Failure, 18 Inches.
" B 31 to 38 " " , 2 " .
" D 35 " , 2 in. Hole.
" D 36 " , 3 " " .
" D 38 " , 6 " " .
" D 39 " , 1 " " .
" D 40 " , 2 " " .
" E 29 " , 2 " " .
" E 31 " , 3 " " .
" E 32 " , 6 " " .
" E 35 " .
" E 36 " , 3 " " .
" I 49 Accidental Hole.

Sheets S 33 to 42 incl. Failure.
" X 33 to 42 " " .
" Z 422, 423 " .
" O 29 to 36 " " .

— BUCK —

Sheets AA 21 to 24 incl. Near Failure.
" CC 17 Slight Lamination.
" A 31 to 34 incl. Failure.
" D 30, 31, 33, 34 " .
" S 29 to 32 incl. " .
" X 29 to 32 " " .
" O 25 to 28 " " , Sheets nearly Gone.
" Z 6, 7, 11 " , (No Record)
" AA 25 to 30 " " .
" AA* 50 to 56 " " .
" A 35 to 47 " " .
" B 37 " .
" B 38 " , Damaged.

Sheets D 35 to 40 incl. Failure.
" E 29 to 32 " " .
" E 35 to 36 " " .
" I 50 Accidental Hole.
" S 33 to 42 " Failure.
" X 33 to 42 " " .
" Z 422, 423, 424 " .
" O 29 to 36 incl. " , Sheets nearly Gone.
(No Record)

(TL Indicates Medium Adherence.)

Sh

ion of Corrosion Test Sheets, at Pittsburgh, Pa., April 1, 1919.

ICAN SOCIETY FOR TESTING MATERIALS

COMMITTEE A-5 ON CORROSION OF IRON AND STEEL
TESTS OF UNCOATED SHEETS
PITTSBURGH, PA.

EXPOSED DECEMBER 12, 1916

Weather *Cold and Clou*

Color 2 Buck	Color 3 Cooper	Color 4 Fleming	Color 5 Gibboney	Color 6 McAdam	Color 7 McDonnell	Color 8 Smith	Color 9 Wheaton	Adherence 1 Aupperle	Adherence 2 Buck	Adherence 3 Cooper	Adherence 4 Fleming	Adherence 5 Gibboney	Adherence 6 McAdam	Adherence 7 McDonnell	Adherence 8 Smith	Adherence 9 Wheaton
L	L	L	M		L	L	D	L	L	L	L	L		L	L	T
L	L	L	M		L	L	D	L	L	L	L	L		L	L	T
L	L	L	M		L	L	D	L	L	L	L	L		L	L	T
L	L	L	M		L	L	D	L	L	L	L	L		L	L	T
L	L	L	M		L	L	D	L	L	L	L	L		L	L	T
L	L	L	M		L	L	D	L	L	L	L	L		L	L	T
L	L	L	M		L	L	D	L	L	L	L	L		L	L	T
L	L	L	M		L	L	D	L	L	L	L	L		L	L	T
L	L	L	M		L	L	D	L	L	L	L	L		L	L	T
L	L	L	M		L	L	D	L	L	L	L	L		L	L	T
D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
L	L	L	M		L	L	M	L	L	L	L	L		L	L	T
L	L	L	M		L	L	M	L	L	L	L	L		L	L	T
D	D	D	D		D	M	D	L	T	T	T	T		T	T	T
D	D	D	D		D	M	D	L	T	T	T	T		T	T	T
D	D	D	D		D	M	D	L	T	T	T	T		T	T	T
D	D	D	D		D	D	D	L	T	T	T	T		T	T	T
D	D	D	D		D	D	D	L	T	T	T	T		T	T	T
D	D	D	D		D	D	D	L	T	T	T	T		T	T	T
D	D	D	D		D	D	D	L	T	T	T	T		T	T	T
D	D	D	D		D	D	D	L	T	T	T	T		T	T	T
L	L	L	M		L	L	M	L	L	L	L	L		L	L	L
L	L	L	M		L	L	M	L	L	L	L	L		L	L	L
L	L	L	M		L	L	M	L	L	L	L	L		L	L	L
L	L	L	M		L	L	M	L	L	L	L	L		L	L	L
L	L	L	M		L	L	M	L	L	L	L	L		L	L	L
L	L	L	M		L	L	M	L	L	L	L	L		L	L	L
L	L	L	M		L	L	M	L	L	L	L	L		L	L	L
L	L	L	M		L	L	M	L	L	L	L	L		L	L	L
M	M	D	D		D	M	D	L	T	T	T	T		T	T	T
M	M	D	D		D	M	D	L	T	T	T	T		T	T	T
M	M	D	D		D	M	D	L	T	T	T	T		T	T	T
M	M	D	D		D	M	D	L	T	T	T	T		T	T	T
M	M	D	D		D	M	D	L	T	T	T	T		T	T	T
M	M	D	D		D	M	D	L	T	T	T	T		T	T	T
M	M	D	D		D	M	D	L	T	T	T	T		T	T	T
M	M	D	D		D	M	D	L	T	T	T	T		T	T	T
L	L	L	L		L		M	L	L	L	L	L		L		L
L	L	L	L		L		M	L	L	L	L	L		L		L
L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
M	D	M	D		D	M	D	T	TL	T	M	T		T	T	T
M	D	M	D		D	M	D	T	TL	T	M	T		T	T	T
M	D	M	D		D	M	D	T	TL	T	M	T		T	T	T
M	D	M	D		D	M	D	T	TL	T	M	T		T	T	T
M	D	L	D		M	M	M	T	TL	T	L	T		L	T	T
M	D	L	D		M	M	M	T	TL	T	L	T		L	T	T
M	D	L	D		M	M	M	T	TL	T	L	T		L	T	T
M	D	L	D		M	M	M	T	TL	T	L	T		L	T	T
M	D	M	D		D	M	D	T	TL	T	M	T		T	T	T
M	M	D	D		D	M	D	T	T	T	T	T		T	T	T
M	M	D	D		D	M	D	T	T	T	T	T		T	T	T
M	M	D	D		D	M	D	T	T	T	T	T		T	T	T
M	M	D	D		D	M	D	T	T	T	T	T		T	T	T
M	M	D	D		D	M	D	T	T	T	T	T		T	T	T
M	M	D	D		D	M	D	T	T	T	T	T		T	T	T
M	M	D	D		D	M	D	T	T	T	T	T		T	T	T

ROW No. 6

Mark	Sheet No.	Texture 1 Aupperle	Texture 2 Buck	Texture 3 Cooper	Texture 4 Fleming	Texture 5 Gibboney	Texture 6 McAdam	Texture 7 McDonnell	Texture 8 Smith	Texture 9 Wheaton	Color 1 Aupperle	Color 2 Buck	Color 3 Cooper	Color 4 Fleming	Color 5 Gibboney	Color 6 McAdam	Color 7 McDonnell	Color 8 Smith	Color 9 Wheaton	Adherence 1 Aupperle	Adherence 2 Buck	Adherence 3 Cooper	Adherence 4 Fleming	Adherence 5 Gibboney	Adherence 6 McAdam	Adherence 7 McDonnell	Adherence 8 Smith	Adherence 9 Wheaton
D	35	VC	VC	C	VC	C		VC	C	C	L	L	L	L	M		L	L	M	L	L	L	L	L		L	L	T
	36	VC	VC	C	VC	C		VC	C	C	L	L	L	L	M		L	L	M	L	L	L	L	L		L	L	T
	38	VC	VC	C	VC	C		VC	C	C	L	L	L	L	M		L	L	M	L	L	L	L	L		L	L	T
	39	VC	VC	C	VC	C		VC	C	C	L	L	L	L	M		L	L	M	L	L	L	L	L		L	L	T
	40	VC	VC	C	VC	C		VC	C	C	L	L	L	L	M		L	L	M	L	L	L	L	L		L	L	T
E	29	S	S	M	M	M		M	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		L	T	T
	30	S	S	M	M	M		M	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		L	T	T
	31	S	S	M	M	M		M	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		L	T	T
	32	S	S	M	M	M		M	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		L	T	T
	33	S	S	M	M	M		M	M	M	D	D	D	D	D		D	M	D	T	T	T	T	T		L	T	T
	34	S	S	M	M	M		M	M	M	D	D	D	D	D		D	M	D	T	T	T	T	T		L	T	T
	35	S	S	M	M	M		M	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		L	T	T
	36	S	S	M	M	M		M	S	M	D	D	D	D	D		D	M	D	T	T	T	T	T		L	T	T
H	43	S	S	S	M	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	45	S	S	S	M	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	47	S	S	S	M	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	49	S	S	S	M	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	50	S	S	S	M	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	53	S	S	S	M	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	54	S	S	S	M	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	55	S	S	S	M	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
I	42	S	VS	S	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	43	S	VS	S	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	44	S	VS	S	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	45	S	VS	S	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	46	S	VS	S	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	47	S	VS	S	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	48	S	VS	S	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	49	S	VS	S	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	50	S	VS	S	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	51	S	VS	S	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	52	S	VS	S	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	53	S	VS	S	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	54	S	VS	S	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	55	S	VS	S	S	S		S	S	M	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
K	37	S	VS	S	S	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	38	S	VS	S	S	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	TL	T
	39	S	VS	S	S	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	40	S	VS	S	S	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	41	S	VS	S	S	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	42	S	VS	S	S	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	43	S	VS	S	S	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	44	S	VS	S	S	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	45	S	VS	S	S	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	46	S	VS	S	S	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	47	S	VS	S	S	S		S	S	S	D	D	D	D	D		D	D	D	T	T	T	T	T		T	T	T
	48	S	VS	S	S	S		S	S	S	D	D	D	D	D		D	D	D		T	T	T	T		T	T	T
M	33	C	M	M	S	M		M	M	M	M	M	M	D	D		D	M	D	T	TL	T	T	T		T	L	T
	34	C	M	M	S	M		M	M	M	M	M	M	D	D		D	M	D	T	TL	T	T	T		T	L	T
	35	C	M	M	S	M		M	M	M	M	M	M	D	D		D	M	D	T	TL	T	T	T		T	L	T
	36	C	M	M	S	M		M	M	M	M	M	M	D	D		D	M	D	T	TL	T	T	T		T	L	T
	37	C	M	M	S	M		M	M	M	M	M	M	D	D		D	M	D	T	TL	T	T	T		T	L	T
	38	C	M	M	S	M		M	M	M	M	M	M	D	D		D	M	D	T	TL	T	T	T		T	L	T
	39	C	M	M	S	M		M	M	M	M	M	M	D	D		D	M	D	T	TL	T	T	T		T	L	T
	40	C	M	M	S	M		M	M	M	M	M	M	D	D		D	M	D	T	TL	T	T	T		T	L	T
	41	C	M	M	S	M		M	M	M	M	M	M	D	D		D	M	D	T	TL	T	T	T		T	L	T
	42	C		M	S	M		M	M	M	M	M	M	D	D		D	M	D	T	TL	T	T	T		T	L	T
S	33	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	34	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	35	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	36	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	37	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	38	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	39	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	40	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	41	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	42	VC	VC	VC	VC	VC		VC	VC	VC	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L

ROW No. 7

Mark	Sheet No.	Texture 1 Aupperle	Texture 2 Buck	Texture 3 Cooper	Texture 4 Fleming	Texture 5 Gibboney	Texture 6 McAdam	Texture 7 McDonnell	Texture 8 Smith	Texture 9 Wheaton	Color 1 Aupperle	Color 2 Buck	Color 3 Cooper	Color 4 Fleming	Color 5 Gibboney	Color 6 McAdam	Color 7 McDonnell	Color 8 Smith	Color 9 Wheaton	Adherence 1 Aupperle	Adherence 2 Buck	Adherence 3 Cooper	Adherence 4 Fleming	Adherence 5 Gibboney	Adherence 6 McAdam	Adherence 7 McDonnell	Adherence 8 Smith	Adherence 9 Wheaton
T	33	S	S	M	S	S		M	S	S	D	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	34	S	S	M	S	S		M	S	S	D	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	35	S	S	M	S	S		M	S	S	D	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	36	S	S	M	S	S		M	S	S	D	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	37	S	S	M	S	S		M	S	S	D	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	38	S	S	M	S	S		M	S	S	D	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	39	S	S	M	S	S		M	S	S	D	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	40	S	S	M	S	S		M	S	S	D	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	41	S	S	M	S	S		M	S	S	D	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	42	S	S	M	S	S		M	S	S	D	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
U	33	M	S	M	S	S		M	S	S	D	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	34	M	S	M	S	S		M	S	S	D	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	35	M	S	M	S	S		M	S	S	D	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	36	M	S	M	S	S		M	S	S	D	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	37	M	S	M	S	S		M	S	S	D	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	38	M	S	M	S	S		M	S	S	D	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	39	M	S	M	S	S		M	S	S	D	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	40	M	S	M	S	S		M	S	S	D	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	41	M	S	M	S	S		M	S	S	D	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	42	M	S	M	S	S		M	S	S	D	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
V	33	M	S	M	S	S		M	S	M	M	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	34	M	S	M	S	S		M	S	M	M	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	35	M	S	M	S	S		M	S	M	M	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	36	M	S	M	S	S		M	S	M	M	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	37	M	S	M	S	S		M	S	M	M	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	38	M	S	M	S	S		M	S	M	M	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	39	M	S	M	S	S		M	S	M	M	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	40	M	S	M	S	S		M	S	M	M	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	41	M	S	M	S	S		M	S	M	M	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
	42	M	S	M	S	S		M	S	M	M	D	M	D	D		D	M	D	T	T	T	T	T		T	T	T
X	33	VC	VC	VC	VC	VC		VC	VC	C	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	34	VC	VC	VC	VC	VC		VC	VC	C	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	35	VC	VC	VC	VC	VC		VC	VC	C	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	36	VC	VC	VC	VC	VC		VC	VC	C	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	37	VC	VC	VC	VC	VC		VC	VC	C	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	38	VC	VC	VC	VC	VC		VC	VC	C	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	39	VC	VC	VC	VC	VC		VC	VC	C	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	40	VC	VC	VC	VC	VC		VC	VC	C	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	41	VC	VC	VC	VC	VC		VC	VC	C	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
	42	VC	VC	VC	VC	VC		VC	VC	C	L	L	L	L	L		L	L	M	L	L	L	L	L		L	L	L
Z	314	VS	VS	S	VS	VS		S	S	S	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	422	VC	VC	VC	VC	VC		VC	VC	C	L	L	L	L	M		L	L	D	L	L	L	L	L		L	L	T
	423	VC	VC	VC	VC	VC		VC	VC	C	L	L	L	L	M		L	L	D	L	L	L	L	L		L	L	T
	424	VC	VC	VC	VC	VC		VC	VC	C	L	L	L	L	M		L	L	D	L	L	L	L	L		L	L	T
	509	VS	VS	VS	S	VS		S	VS	S	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	513	VS	VS	VS	S	VS		S	VS	S	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	516	VS	VS	VS	S	VS		S	VS	S	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	607	VS	VS	VS	S	VS		S	VS	S	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	608	VS	VS	VS	S	VS		S	VS	S	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	609	VS	VS	VS	S	VS		S	VS	S	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	712	VS	VS	VS	S	VS		S	VS	S	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	714	VS	VS	VS	S	VS		S	VS	S	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
	715	VS	VS	VS	S	VS		S	VS	S	D	D	D	D	D		D	M	D	T	T	T	T	T		T	T	T
O	29	VC			VC	VC				C	L			L	L				M	L			L	L				L
	30	VC			VC	VC				C	L			L	L				M	L			L	L				L
	31	VC			VC	VC				C	L			L	L				M	L			L	L				L
	32	VC			VC	VC				C	L			L	L				M	L			L	L				L
	33	VC			VC	VC				C	L			L	L				M	L			L	L				L
	34	VC			VC	VC				C	L			L	L				M	L			L	L				L
	35	VC			VC	VC				C	L			L	L				M	L			L	L				L
	36	VC			VC	VC				C	L			L	L				M	L			L	L				L
Y*	7	C	VC	C	VC	C		VC	C	C	L	L	L	L	M		L	M	M	L	L	L	L	T		L	L	T
	8	C	VC	C	VC	C		VC	C	C	L	L	L	L	M		L	M	M	L	L	L	L	T		L	L	T
	9	C	VC	C	VC	C		VC	C	C	L	L	L	L	M		L	M	M	L	L	L	L	T		L	L	T
YY*	7	C	VC	C	VC	C		VC	C	C	L	L	L	L	M		L	M	M	L	L	L	L	L		L	L	T
	8	C	VC	C	VC	C		VC	C	C	L	L	L	L	M		L	M	M	L	L	L	L	L		L	L	T
	9	C	VC	C	VC	C		VC	C	C	L	L	L	L	M		L	M	M	L	L	L	L	L		L	L	T

* Exposed 6-8-17

— M

Sheets	CC	17 F
"	A	31 to 3
"	D	30,31,
"	S	29 to
"	X	29 to
"	O	25 to
"	Z	6,7,
"	AA	25 to
"	AA*	50 to
"	A	35 to
"	B	37
"	D	35 to
"	E	29
"	E	30
"	E	31
"	E	32
"	E	35
"	E	36
"	I	50
"	S	33 to
"	X	33 to
"	Z	422,4
"	O	29 to

— S

Sheets	CC	17
"	A	31 to
"	D	30,31,
"	S	29 to
"	X	29 to
"	O	25 to
"	Z	6,7,1
"	AA	25 to
"	AA*	50 to
"	A	35 to
"	A	37 to
"	B	37 to
	D	36 to
	D	39 to
	E	29
	E	31
	E	32
	E	35
	E	36
	I	50
	S	33 to
	V	40
	X	33 to
	Z	422,42
	O	29 to

ts	D	35 to 40 incl.	Failure.
	E	29 to 32 "	" .
	E	35 to 36 "	" .
	I	50	Accidental Hole
	S	33 to 42 "	Failure.
	X	33 to 42 "	" .
	Z	422,423,424	" .
	O	29 to 36 incl.	" , Sheets nearly Gone. (No Record)

(TL Indicates Medium Adherence.)

— COOPER —

Sheets	CC	17	Break in Upper Left Hand Side Caused by a Laminated Spot in Sheet.
"	A	31 to 34 incl.	Bottom of Sheets all Gone.
"	D	30,31,33,34	" " " " " .
"	S	29 to 32 incl.	" " " " " .
"	X	29 to 32 "	" " " " " .
"	O	25 to 28 "	Sheets all Gone; no Record.
"	Z	6,7,11	Bottom of Sheets all Gone.
"	A	35	Sheet all Gone.
"	A	36 to 47 "	Sheets " " at Bottom.
"	B	37 to 38 "	Holes in Bottom, Accident; Sheets Bent.

Sheets	AA	25 to 30	Bottom of Sheets all Gone.
"	D	35	Hole in Sheet.
"	D	36,38,39,40	Beginning to go at Bottom of Sheets.
"	E	29,31,32,35,36	Holes in Sheets near Bottom.
"	I	50	Hole Punched in Sheets by Accident.
"	S	33 to 42 incl.	All Gone.
"	X	33 to 42 "	About all Gone.
"	O	29 to 36 "	All Gone, no Record.
"	AA*	50 to 56 "	Bottom of Sheets all Gone

(TL Indicates Medium Adherence.)

— FLEMING —

Sheets	CC	17	Accidental Crack.
"	A	31 to 34 incl.	Failed
"	D	30,31,33,34	" .
"	S	29 to 32 incl.	" .
"	X	29 to 32 "	" .
"	O	25 to 28 "	" .
"	Z	6,7,11	" .
"	AA	25 to 30 "	" .
"	AA*	50 to 56 "	" .
"	A	35 to 47 "	" .
"	B	37	" .
"	B	38	Hole by Damage.
"	D	36,38,39,40	Failed.

Sheets	E	29,31,32,3
"	I	50
"	S	33 to 42 in
"	X	33 to 42
"	Z	422,423,4
"	O	29 to 36

Cloudy.

— McDONNELL —

CC	17	Break on Left Edge, which was apparently Due to Accident.
A	31 to 34 incl.	Failed approximately 10 Inches off of Lower Ends.
D	30, 31, 33, 34	All Failed, Lower Ends.
S	29 to 32 incl.	Failed approximately 10 Inches off of Lower Ends.
X	29 to 32 "	" " " " " " " "
O	25 to 28 "	" ; only Small Fragments Remaining on Upper Rail of Rack; no Record.
Z	6, 7, 11	" approximately 12 to 15 Inches off of Lower Ends.
AA	25 to 30 "	" ; Corroded through at Lower Ends.
AA*	50 to 56 "	" " " " " " " .
A	35 to 47 "	" ; approximately 10 Inches Gone from Bottom of Panels. Also Some Holes.
		A 33, 37, 38 Cracked, probably by Accident.
B	37	Failed, two Holes.
D	35 to 40 incl.	All Failed.
E	28	One Hole.
E	30	" Small Hole.
E	31	Cracked.
E	32	One Large Hole.
E	35	Cracked, also One Hole.
E	36	Hole near Bottom End.
I	50	One Accidental Hole.
S	33 to 42 "	All Failed 6 to 12 Inches from Lower Ends.
X	33 to 42 "	" " .
Z	422, 423, 424	" " .
O	29 to 36 incl.	" " ; only Small Fragments Remaining on Upper Rail of Test Rack. No Record.

— WHEATON —

Sheets	CC	17	1½" Tear on Left Edge.
"	A	31 to 34 incl.	Failed.
"	D	30, 31, 33, 34	" .
"	S	29 to 32 incl.	" .
"	X	29 to 32 "	" .
"	O	25 to 28 "	" .
"	Z	6, 7, 11	" .
"	AA	25 to 30 "	" .
"	AA*	50 to 56 "	" .
"	A	35 to 47 "	" .
"	B	37 to 38	" .
"	D	35 to 40 "	" .
"	E	29 to 32 "	" .
"	E	35 to 36	" .
"	I	50	Bullet Hole.
"	S	33 to 42 "	Failed.
"	V	40	Bullet Hole.
"	X	33 to 42 "	Failed.
"	Z	422, 423, 424	" .
"	O	29 to 36 incl.	" .

— SMITH —

CC	17	Accidental Crack.
A	31 to 34 incl.	Lower Ends Failed.
D	30, 31, 33, 34	" " " .
S	29 to 32 incl.	Badly Failed at Bottom.
X	29 to 32 "	Failed at Lower Ends.
O	25 to 28 "	All Gone. No Record.
Z	6, 7, 11	Failed at Lower Ends.
AA	25 to 30 "	Slight Failure at Lower Ends.
AA*	50 to 56 "	Failed.
A	35 to 36 "	All Gone.
A	37 to 47 "	Badly Failed.
B	37 to 38	Accidental Cracks have Caused Failure at Bottom.
D	36 to 38 "	Hole at Lower End.
D	39 to 40	Lower Corner Failed.
E	29	Crack; Lower End.
E	31	Hole; " " .
E	32	Large Hole near Lower End.
E	35	Hole; Lower End.
E	36	" near Lower End.
I	50	Punched Hole.
S	33 to 42 "	All Failed.
V	40	Bullet Hole.
X	33 to 42 "	All Failed.
Z	422, 423, 424	" " .
O	29 to 36 incl.	" " . No Record.

29, 31, 32, 35, 36	Failed.
50	Rifle Hole.
33 to 42 incl.	Failed.
33 to 42 "	" .
422, 423, 424	" .
29 to 36 incl.	" .

— GIBBONEY —

Sheets	CC	17	Crack, Laminated Sheet.
"	A	31 to 34 incl.	Failure, Lower Ends.
"	D	30, 31, 33, 34	" " " .
"	S	29 to 32 incl.	" " " .
"	X	29 to 32 "	" " " .
"	O	25 to 28 "	" ; All Gone.
"	Z	6, 7, 11	" , Lower Ends.
"	AA	25 to 30 "	" " " .
"	AA*	50 to 56 "	" " "
"	A	35 to 47 "	" ; All Gone.
"	B	37 to 38 "	Slight " at Lower Ends.
"	D	36 to 40 "	" " " " .
"	E	29 to 32 " "	" " " " .
Sheets	E	35 to 36 incl.	Slight Failure at Lower Ends.
"	I	50	Accidental Hole.
"	S	33 to 42 "	Failure, Lower Ends.
"	V	40	Accidental Hole.
"	X	33 to 42 "	Failure; All Gone.
"	Z	422, 423, 424	" , Lower Ends.
"	O	29 to 36 incl.	" ; All Gone

— McADAM —

Did not make this Inspection.

James H. Gibboney.

Chairman Inspection Committee

Table V.—Pittsburgh Tests. Inspection of October 7, 1918.

Type Designation.	Average Texture.		Color.	Adherence.
	Numerical Value.	Symbol.		
No. 16 Gage.				
ZZ (HC)	4.500	V S	D	T
II	4.431	V S	D	T
KK	4.177	S	D	T
HH	4.025	S	D	T
TT	3.982	S	D	T
VV	3.923	S	D	T
UU	3.839	S	D	T
EE	3.813	S	D	T
CCC	3.333	M	D	T
BB	2.860	M	D	T
MM	2.804	M	D	T
CC	2.625	M	M	T
ZZ (LC)	2.375	C	M	L
DD	2.139	C	M	L
OO	2.083	C	M	L
YY	2.000	C	M	L
XX	1.643	V C	M	L
SS	1.125	V C	L	L
AA	1.037	V C	L	L
No. 22 Gage.				
I	4.472	V S	D	T
Z (HC)	4.294	V S	D	T
K	4.187	S	D	T
T	4.107	S	D	T
H	4.000	S	D	T
U	3.875	S	D	T
V	3.839	S	D	T
B	3.567	S	D	T
E	3.385	M	D	T
C	3.273	M	D	T
M	2.732	M	D	T
Y	2.500	C	M	T
Z (LC)	1.813	C	L	L
D	1.667	V C	M	L
X	1.214	V C	L	L
A	1.125	V C	L	L
O	1.091	V C	L	L
S	1.000	V C	L	L

Note.—ZZ (HC) indicates copper 0.153 to 0.662 per cent.
ZZ (LC) indicates copper 0.034 per cent or under.
Z (HC) indicates copper 0.126 to 0.712 per cent.
Z (LC) indicates copper 0.020 per cent or under.

The above table has been compiled from the composite inspection report by averaging the reports on texture on each sheet by each inspector. The arbitrary figures used in these averages are as follows:

Very coarse	1
Coarse	2
Medium	3
Smooth	4
Very smooth	5

The numerical values thus obtained have been translated back into symbols, using the following scale:

1.0 to 1.8	Very coarse (VC)
1.8 to 2.6	Coarse (C)
2.6 to 3.4	Medium (M)
3.4 to 4.2	Smooth (S)
4.2 to 5.0	Very smooth (VS)

In the case of color and adherence, it being impractical to ascribe satisfactory numerical values, the symbols in the table represent the majority opinions of the inspectors.

TABLE VI.—ANNAPOLIS TESTS. INSPECTION OF OCTOBER 8, 1918.

Type Designation.	Average Texture.		Color.	Adherence.
	Numerical Value.	Symbol.		
No. 16 Gage.				
ZZ (HC)	3.949	S	D	T
II	3.902	S	D	T
KK	3.698	S	D	T
HH	3.616	S	D	T
TT	3.510	S	D	T
EE	3.179	M	M	T
VV	3.061	M	M	T
MM	3.031	M	D	T
UU	3.031	M	M	T
BB	3.008	M	D	T
ZZ (LC)	2.881	M	M	L
CCC	2.667	M	M	L
CC*	2.536	C	L	L
OO	2.464	C	D	L
DD	2.353	C	M	L
XX	2.316	C	M	L
SS	2.061	C	L	L
AA**	1.739	V C	M	L
YY	1.571	V C	L	L

* CC (Sand blasted).
** AA (Sand blasted).

Type Designation.	Numerical Value.	Symbol.	Color.	Adherence.
No. 22 Gage.				
I	3.795	S	D	T
T	3.683	S	D	T
Z (HC)	3.659	S	D	T
K	3.652	S	D	T
H	3.509	S	D	T
E	3.299	M	M	T
V	3.000	M	M	T
U	2.918	M	M	T
B	2.857	M	M	T
M	2.776	M	M	T
C	2.571	C	M	T
Z (LC)	2.500	C	M	L
D	2.367	C	L	L
A	2.286	C	M	L
X	2.173	C	M	L
S	2.112	C	L	L
Y	1.857	C	L	L
O	1.607	V C	M	L

NOTE.—ZZ (HC) indicates copper 0.153 to 0.662 per cent.
ZZ (LC) indicates copper 0.034 per cent or under.
Z (HC) indicates copper 0.126 to 0.712 per cent.
Z (LC) indicates copper 0.020 per cent or under.

The above table has been compiled from the composite inspection report by averaging the reports on texture on each sheet by each inspector. The arbitrary figures used in these averages are as follows:

Very coarse	1
Coarse	2
Medium	3
Smooth	4
Very smooth	5

The numerical values thus obtained have been translated back into symbols, using the following scale:

1.0 to 1.8	Very coarse (VC)
1.8 to 2.6	Coarse (C)
2.6 to 3.4	Medium (M)
3.4 to 4.2	Smooth (S)
4.2 to 5.0	Very smooth (VS)

In the case of color and adherence, it being impractical to ascribe satisfactory numerical values, the symbols in the table represent the majority opinions of the inspectors.

TABLE VII.—FORT SHERIDAN TESTS. INSPECTION OF MARCH 31, 1919.

Type Designation.	Average Texture.		Color.	Adherence.
	Numerical Value.	Symbol.		
No. 16 Gage.				
ZZ (HC)	4.156	S	D	T
KK	4.098	S	M	T
II	3.977	S	M	T
HH	3.756	S	D	T
TT	3.571	S	D	T
EE	3.357	M	M	T
UU	3.286	M	M	T
VV	3.286	M	M	T
BB	3.252	M	M	T
DD	2.782	M	M	T
CCC	2.750	M	M	T
MM	2.663	M	M	T
OO	2.643	M	M	T
CC	2.583	C	M	T
ZZ (LC)	2.571	C	L	T
SS	2.143	C	L	T
YY	2.143	C	M	T
XX	2.122	C	M	T
AA	1.802	C	L	L
No. 22 Gage.				
Z (HC)	4.120	S	D	T
K	4.116	S	D	T
I	4.000	S	M	T
V	3.592	S	M	T
T	3.479	S	D	T
H	3.402	S	M	T
E	3.285	M	M	T
C	3.218	M	M	T
B	3.209	M	M	T
U	3.122	M	M	T
M	3.061	M	M	T
D	2.572	C	M	T
Z (LC)	2.385	C	M	L
X	2.316	C	L	L
Y	2.095	C	L	T
S	2.061	C	L	L
O	1.857	C	L	L
A	1.828	C	L	L

NOTE.—ZZ (LC) indicates copper 0.034 or under.
ZZ (HC) indicates copper 0.153 to 0.662 per cent.
Z (LC) indicates copper 0.020 or less.
Z (HC) indicates copper 0.126 to 0.712 per cent.

The above table has been compiled from the composite inspection report by averaging the reports on texture on each sheet by each inspector. The arbitrary figures used in these averages are as follows:

Very coarse	1
Coarse	2
Medium	3
Smooth	4
Very smooth	5

The numerical values thus obtained have been translated back into symbols, using the following scale:

1.0 to 1.8	Very coarse (VC)
1.8 to 2.6	Coarse (C)
2.6 to 3.4	Medium (M)
3.4 to 4.2	Smooth (S)
4.2 to 5.0	Very smooth (VS)

In the case of color and adherence, it being impractical to ascribe satisfactory numerical values, the symbols in the table represent the majority opinions of the inspectors.

TABLE VIII.—PITTSBURGH TESTS. INSPECTION OF APRIL 1, 1919.

Type Designation.	Average Texture.		Color.	Adherence.
	Numerical Value.	Symbol.		
No. 16 GAGE.				
II	4.271	V S	D	T
ZZ (HC)	4.267	V S	D	T
KK	4.178	S	D	T
TT	4.071	S	D	T
VV	3.910	S	D	T
UU	3.907	S	D	T
HH	3.883	S	D	T
EE	3.792	S	D	T
CCC	3.130	M	D	T
BB	2.941	M	M	T
MM	2.536	C	M	L
CC	2.344	C	M	L
OO	1.708	V C	L	L
YY	1.625	V C	L	L
XX	1.482	V C	L	L
ZZ (LC)	1.450	V C	L	L
DD	1.409	V C	L	L
SS	1.000	V C	L	L
AA	1.000	V C	L	L
No. 22 GAGE.				
Z (HC)	4.522	V S	D	T
K	4.188	S	D	T
I	4.084	S	D	T
H	3.958	S	D	T
T	3.821	S	D	T
U	3.696	S	D	T
V	3.536	S	D	T
E	3.270	M	D	T
C	3.204	M	D	T
B	3.202	M	M	T
M	3.108	M	M	T
Y	1.625	V C	L	L
D	1.333	V C	L	L
Z (LC)	1.187	V C	L	L
O	1.167	V C	L	L
X	1.125	V C	L	L
A	1.029	V C	L	L
S	1.000	V C	L	L

NOTE.—ZZ (LC) indicates copper 0.034 or under.
ZZ (HC) indicates copper 0.153 to 0.662 per cent.
Z (LC) indicates copper 0.020 or less.
Z (HC) indicates copper 0.126 to 0.712

The above table has been compiled from the composite inspection report by averaging the reports on texture on each sheet by each inspector. The arbitrary figures used in these averages are as follows:

Very coarse	1
Coarse	2
Medium	3
Smooth	4
Very smooth	5

The numerical values thus obtained have been translated back into symbols, using the following scale:

1.0 to 1.8	Very coarse (VC)
1.8 to 2.6	Coarse (C)
2.6 to 3.4	Medium (M)
3.4 to 4.2	Smooth (S)
4.2 to 5.0	Very smooth (VS)

In the case of color and adherence, it being impractical to ascribe satisfactory numerical values, the symbols in the table represent the majority opinions of the inspectors.

TABLE IX.—AVERAGE SURFACE TEXTURE, PITTSBURGH TESTS. INSPECTIONS OF 1917, 1918, AND 1919. SHEETS EXPOSED DECEMBER 12, 1916.

Group.	Type Designation.	Date of Inspection.							
		Oct. 9, 1917.		April 9, 1918.		Oct. 7, 1918.		April 1, 1919.	
		Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.
		No. 16 Gage.							
HH	Copper-Bearing Basic Open-hearth Steel, Series A	3.725	S	3.600	S	4.025	S	3.883	S
ZZ (HC)	Copper-Bearing Steel, Series B. Youngstown Sheet and Tube Co	3.684	S	4.266	V S	4.500	V S	4.267	V S
II	Copper-Bearing Bessemer Steel, Series A	3.597	S	4.389	V S	4.431	V S	4.271	V S
TT	Copper-Bearing Steel, Series B. Newport Rolling Mill Co	3.572	S	3.589	S	3.982	S	4.071	S
KK	Copper Bearing Acid Open-hearth Steel, Series A	3.428	S	4.171	V S	4.177	S	4.178	S
UU	Copper-Bearing Pure Iron, Series B. Allegheny Steel Co	3.339	M	3.518	S	3.839	S	3.907	S
CCC	Copper-Bearing Pure Iron, Series A	3.219	M	3.333	M	3.333	M	3.130	M
EE	Puddled Iron, Series A.	3.208	M	3.542	S	3.813	S	3.792	S
BB	Open-hearth Steel, Series A	3.100	M	3.037	M	2.860	M	2.941	M
VV	Copper-Bearing Pure Iron, Series B. Whitaker-Glessner Co	3.087	M	3.529	S	3.923	S	3.910	S
YY[a]	Low-Copper Wrought Iron, Series B. Youngstown Sheet and Tube Co	....	....	3.000	M	2.000	C	1.625	V C
CC	Copper-Bearing Pure Iron, Series A	2.979	M	2.812	M	2.625	M	2.344	C
MM	Open-hearth Steel, Series B. Alan Wood Iron and Steel Co	2.857	M	2.357	C	2.804	M	2.536	C
DD	Low-Copper Pure Iron, Series A	2.521	C	2.215	C	2.139	C	1.409	V C
OO	Low-Copper Open-hearth Steel, Series A	2.167	C	1.500	V C	2.083	C	1.708	V C
ZZ (LC)	Low-Copper Steel, Series B. Youngstown Sheet and Tube Co.	2.150	C	1.600	V C	2.375	C	1.450	V C
XX	Low-Copper Pure Iron, Series B. Inland Steel Co	1.996	C	1.750	V C	1.643	V C	1.482	V C
SS	Low-Copper Pure Iron, Series B. American Rolling Mill Co	1.822	C	1.625	V C	1.125	V C	1.000	V C
AA	Bessemer Steel, Series A	1.162	V C	1.000	V C	1.037	V C	1.000	V C

NOTE.—ZZ (HC) indicates copper 0.153 to 0.662 per cent.
ZZ (LC) indicates copper 0.034 per cent or under.

[a] YY Sheets exposed June 2, 1917.

TABLE IX—*Continued.*

Group.	Type Designation.	Date of Inspection.							
		Oct. 9, 1917.		April 9, 1918.		Oct. 7, 1918.		April 1, 1919.	
		Numerical Value.	Symbol.	Numerical. Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.
		NO. 22 GAGE.							
Z (HC)	Copper-Bearing Steel, Series B. Youngstown Sheet and Tube Co.	3.828	S	4.008	S	4.294	V S	4.522	V S
I	Copper-Bearing Bessemer Steel, Series A	3.819	S	4.118	S	4.472	V S	4.084	S
H	Copper-Bearing Basic Open-hearth Steel, Series A	3.792	S	3.572	S	4.000	S	3.958	S
K	Copper-Bearing Acid Open-hearth Steel, Series A	3.719	S	4.062	S	4.187	S	4.188	S
B	Open-hearth Steel, Series A	3.653	S	3.211	M	3.567	S	3.202	M
T	Copper-Bearing Steel, Series B. Newport Rolling Mill Co.	3.589	S	3.482	S	4.107	S	3.821	S
U	Copper-Bearing Pure Iron, Series B. Allegheny Steel Co.	3.554	S	3.232	M	3.875	S	3.696	S
V	Copper-Bearing Pure Iron, Series B. Whitaker-Glessner Co.	3.464	S	3.304	S	3.839	S	3.536	S
Y[a]	Low-Copper Wrought Iron, Series B. Youngstown Sheet and Tube Co.	....	....	3.250	M	2.500	C	1.625	V C
C	Copper-Bearing Pure Iron, Series A	3.364	M	2.864	M	3.273	M	3.204	M
M	Open-hearth Steel, Series B. Alan Wood Iron and Steel Co.	3.330	M	3.107	M	2.732	M	3.108	M
E	Puddled Iron, Series A.	3.125	M	3.250	M	3.385	M	3.270	M
D	Low-Copper Pure Iron, Series A	2.431	C	1.833	C	1.667	V C	1.333	V C
Z (LC)	Low-Copper Steel, Series B. Youngstown Sheet and Tube Co.	2.142	C	1.803	C	1.813	C	1.187	V C
S	Low-Copper Pure Iron, Series B. American Rolling Mill Co.	1.893	C	1.625	V C	1.000	V C	1.000	V C
X	Low-Copper Pure Iron, Series B. Inland Steel Co.	1.491	V C	1.268	V C	1.214	V C	1.125	V C
A	Bessemer Steel, Series A	1.346	V C	1.000	V C	1.125	V C	1.029	V C
O	Low-Copper Open-hearth Steel, Series A	1.209	V C	1.000	V C	1.091	V C	1.167	V C

NOTE.—Z (HC) indicates copper 0.126 to 0.712 per cent.
Z (LC) indicates copper 0.020 per cent or under.

[a] Y Sheets exposed June 2, 1917.

Table IX has been compiled from the composite inspection reports by averaging the reports on texture on each sheet by each inspector. The arbitrary figures used in these averages are as follows:

Very coarse	1
Coarse	2
Medium	3
Smooth	4
Very smooth	5

The numerical values thus obtained have been translated back into symbols, using the following scale:

1.0 to 1.8	Very coarse (VC)
1.8 to 2.6	Coarse (C)
2.6 to 3.4	Medium (M)
3.4 to 4.2	Smooth (S)
4.2 to 5.0	Very smooth (VS)

TABLE X.—FAILURES AT PITTSBURGH TESTS. INSPECTIONS OF 1917, 1918 AND 1919. SHEETS EXPOSED DECEMBER 12, 1916.

Group.	Type Designation.	Date of Inspection.			
		Oct. 9, 1917. 10 Months.	April 9, 1918. 16 Months.	Oct. 7, 1918. 22 Months.	April 1, 1919. 28 Months.
A	No. 22 Gage Bessemer Steel, Series A (17 Sheets)	None	31, 32, 33, 34, 35, 36, 37, 38, 40, 41, 42, 43, 44, 45, 46, 47. **(16)**	39 **(1)**	....
O	No. 22 Gage Low-Copper Open-hearth Steel, Series A (12 Sheets)	None	25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36. **(12)**	....	....
S	No. 22 Gage Low-Copper Pure Iron, Series B. American Rolling Mill Co (14 Sheets)	None	35 **(1)**	29, 30, 31, 32, 33, 34, 36, 37, 38, 39, 40, 41, 42. **(13)**	....
Z	No. 22 Gage Bessemer Steel, with varying copper content, Series B. Youngstown Sheet and Tube Co (11 Sheets)	None	11 **(1)**	6, 7, 422, 423, 424. **(5)**	....
D	No. 22 Gage Low-Copper Pure Iron, Series A (9 Sheets)	None	None	30, 36, 38. **(3)**	31, 33, 34, 35, 39, 40. **(6)**
X	No. 22 Gage Low-Copper Pure Iron, Series B. Inland Steel Co (14 Sheets)	None	None	29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42. **(14)**	....
B	No. 22 Gage Open-hearth Steel, Series A (13 Sheets)	None	None	37 **(1)**	38 **(1)**
E	No. 22 Gage Puddled Iron, Series A (12 Sheets)	None	None	32, 36. **(2)**	29, 30, 31, 35. **(4)**
AA	No. 16 Gage Bessemer Steel, Series A (17 Sheets)	None	None	None	25, 26, 27, 28, 29, 30, 50, 51, 52, 53, 54, 55, 56. **(13)**

Low-Copper Pure Iron, Series B), manufactured by the American Rolling Mill Co., and X 33 to 42 inclusive (No. 22 Gage Low-Copper Pure Iron, Series B), manufactured by the Inland Steel Co.

The average compositions of each group of sheets are given in Table XI.

Table XI.—Average Compositions of Sheets of Series A, D, O, S and X, which have Completely Failed.

Group.	Type Designation.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.
A 31–47	No. 22 Gage Bessemer Steel, Series A....................	0.037	0.38	0.089	0.040	0.006	0.010
D 30–40	No. 22 Gage Low-Copper Pure Iron, Series A..............	0.024	0.026	0.003	0.020	0.004	0.022
O 25–36	No. 22 Gage Low-Copper Openhearth Steel, Series A........	0.134	0.55	0.008	0.029	0.24	0.018
S 29–42	No. 22 Gage Low-Copper Pure Iron, Series B. American Rolling Mill Co..............	0.018	0.018	0.005	0.025	0.004	0.023
X 29–42	No. 22 Gage Low-Copper Pure Iron, Series B. Inland Steel Co........................	0.021	0.057	0.006	0.031	0.002	0.025

All of the A, D, O, S, and X Sheets exposed at Pittsburgh representing a location selected as an inland industrial center are complete failures, and no further detail record for these sheets will appear in future reports.

Third Meeting.—The third meeting of the sub-committee was held at New York City, on April 25, 1919, with Messrs. Aupperle, Buck, Cooper, Fleming, McDonnell, Smith, Wheaton, Bureau of Steam Engineering of the U. S. Navy Department, Gibboney, Voorhees (*ex officio*) present. The report of the sub-committee was unanimously approved for submission to Committee A-5 at this meeting.

Respectfully submitted on behalf of the sub-committee,

J. H. GIBBONEY,
Chairman.

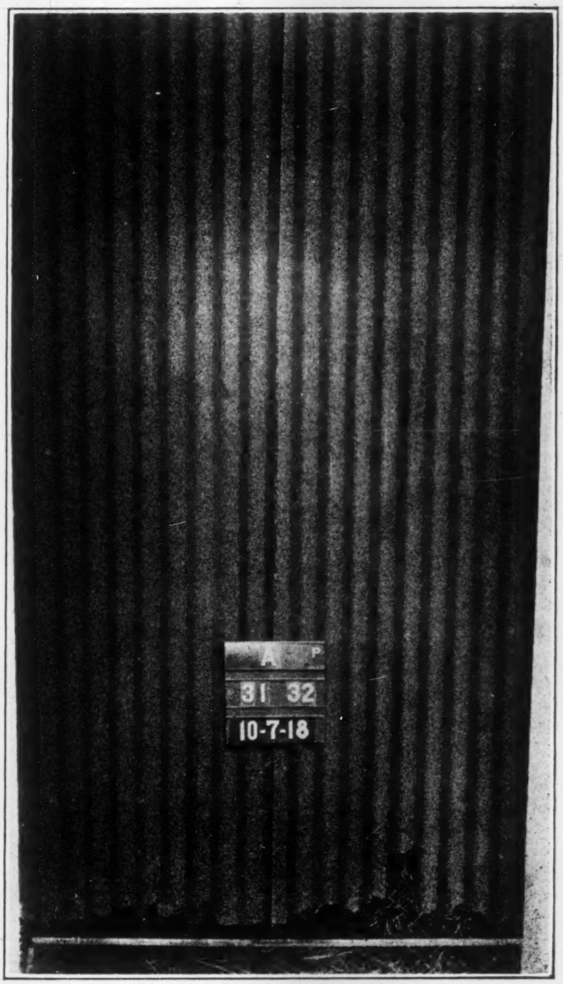

FIG. 1.—PITTSBURGH TESTS.

NO. 22 GAGE BESSEMER STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
A 31.......	0.04	0.35	0.078	0.036	....	0.006	....
A 32.......	0.04	0.36	0.105	0.046	....	0.008	....

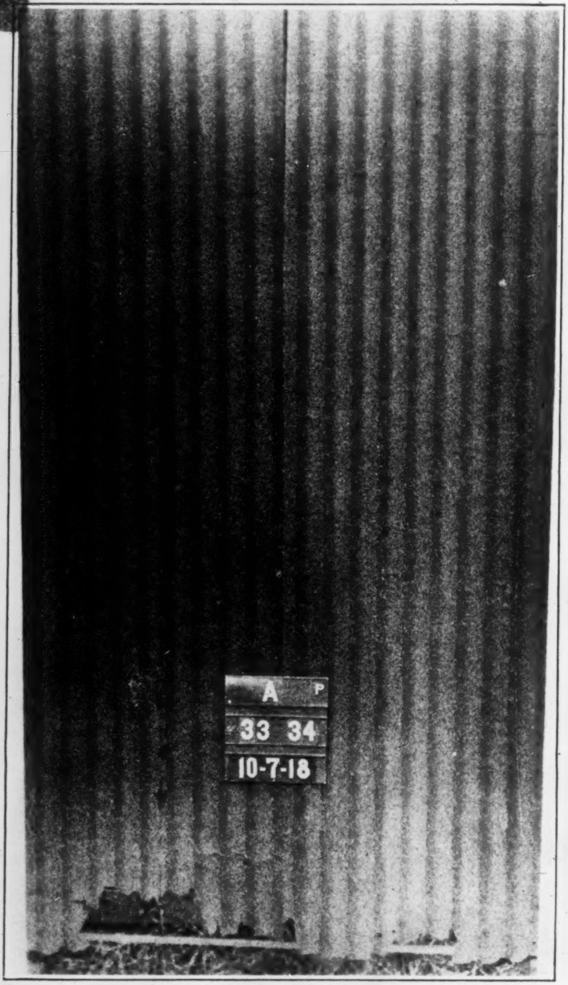

FIG. 2.—PITTSBURGH TESTS.

NO. 22 GAGE BESSEMER STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
A 33.......	0.04	0.36	0.086	0.035	....	0.008	....
A 34.......	0.04	0.38	0.084	0.039	....	0.008	....

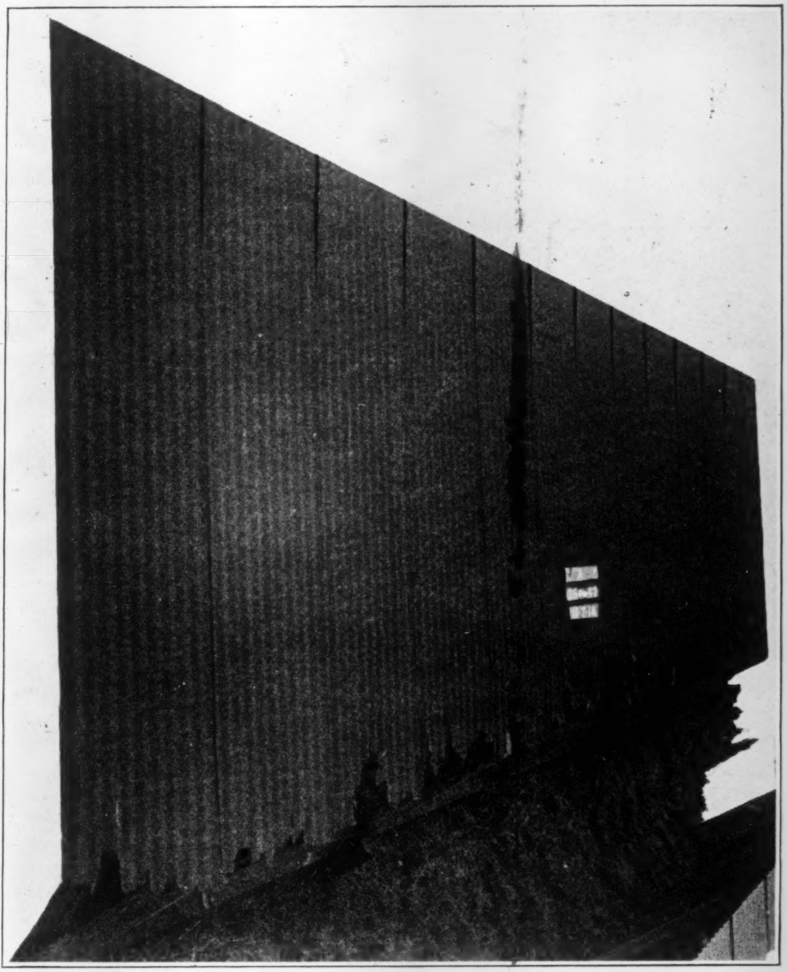

FIG. 3.—PITTSBURGH TESTS.
NO. 22 GAGE BESSEMER STEEL—SERIES A.
Sheets A 35 to 47, inclusive.

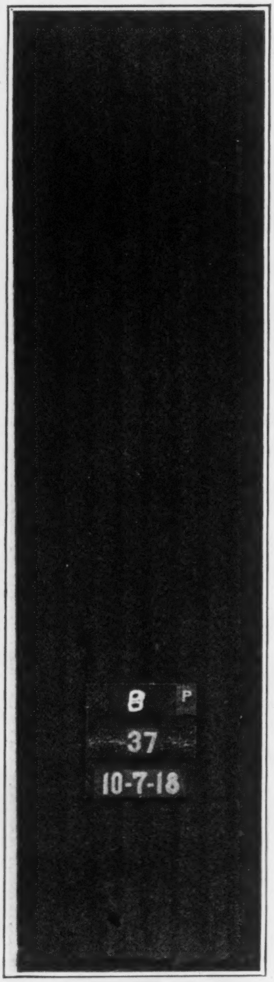

FIG. 4.—PITTSBURGH TESTS.

NO. 22 GAGE OPEN-HEARTH STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
B 37.......	0.08	0.37	0.020	0.046	0.056	0.08	0.055

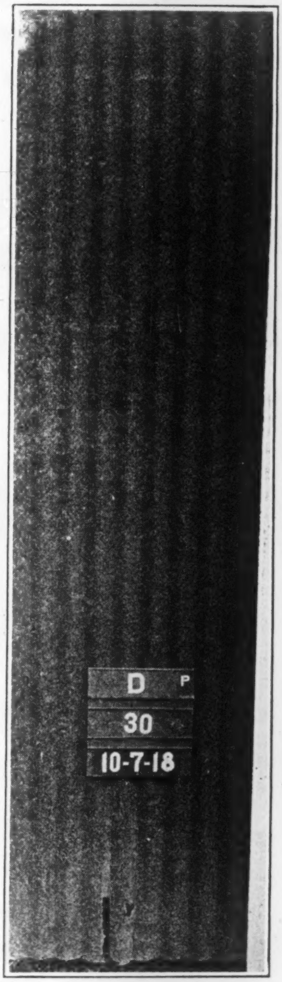

FIG. 5.—PITTSBURGH TESTS.

NO. 22 GAGE LOW COPPER PURE IRON—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
D 30.......	0.02	0.05	0.002	0.018	....	0.02	0.02

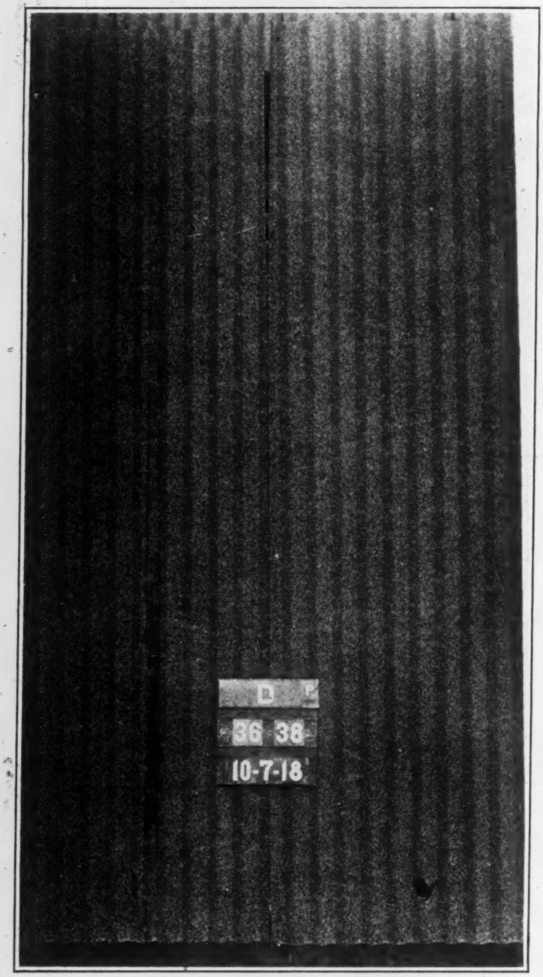

FIG. 6.—PITTSBURGH TESTS.

NO. 22 GAGE LOW COPPER PURE IRON—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
D 36.......	0.02	0.02	0.003	0.021	....	0.014	0.027
D 38.......	0.03	0.02	.003	0.021	0.004	0.016	0.006

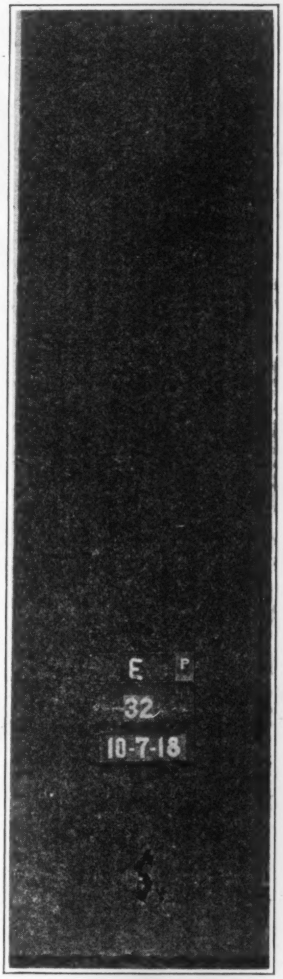

FIG. 7.—PITTSBURGH TESTS.

NO. 22 GAGE PUDDLED IRON—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
E 32.......	0.02	0.02	0.111	0.021	0.141	0.31	0.02

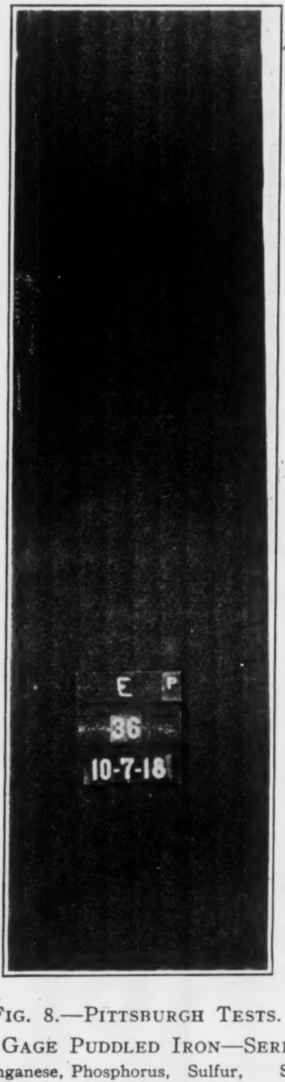

FIG. 8.—PITTSBURGH TESTS.

NO. 22 GAGE PUDDLED IRON—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
E 36.......	0.02	0.02	0.101	0.020	0.141	0.31	0.015

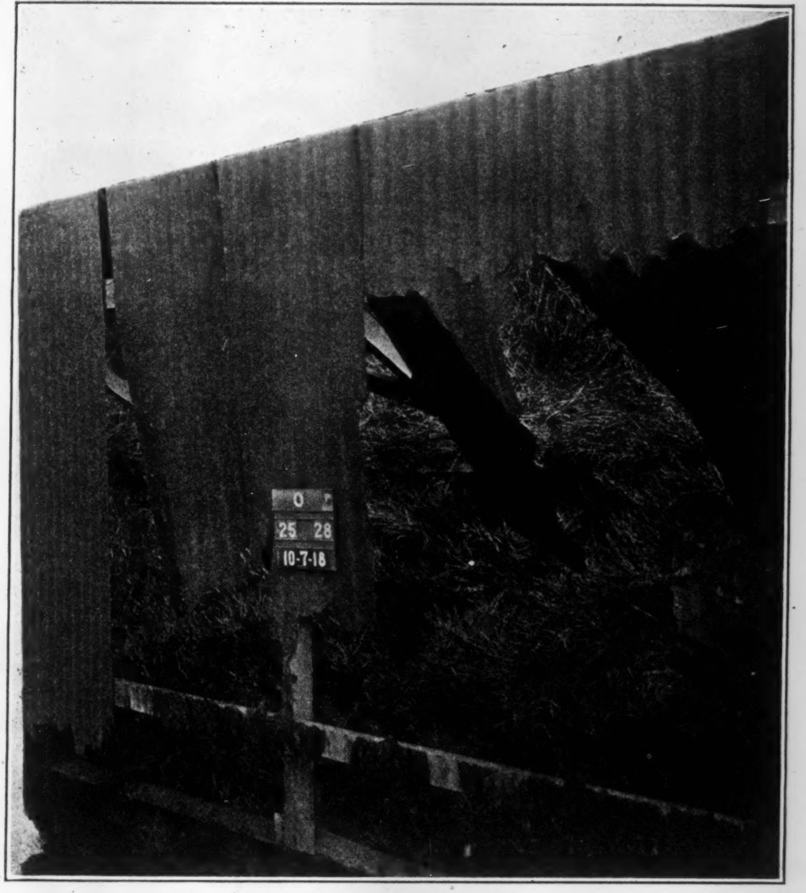

FIG. 9.—PITTSBURGH TESTS.
NO. 22 GAGE LOW COPPER OPEN-HEARTH STEEL.—SERIES A.
Sheets O 25 to 28, inclusive.

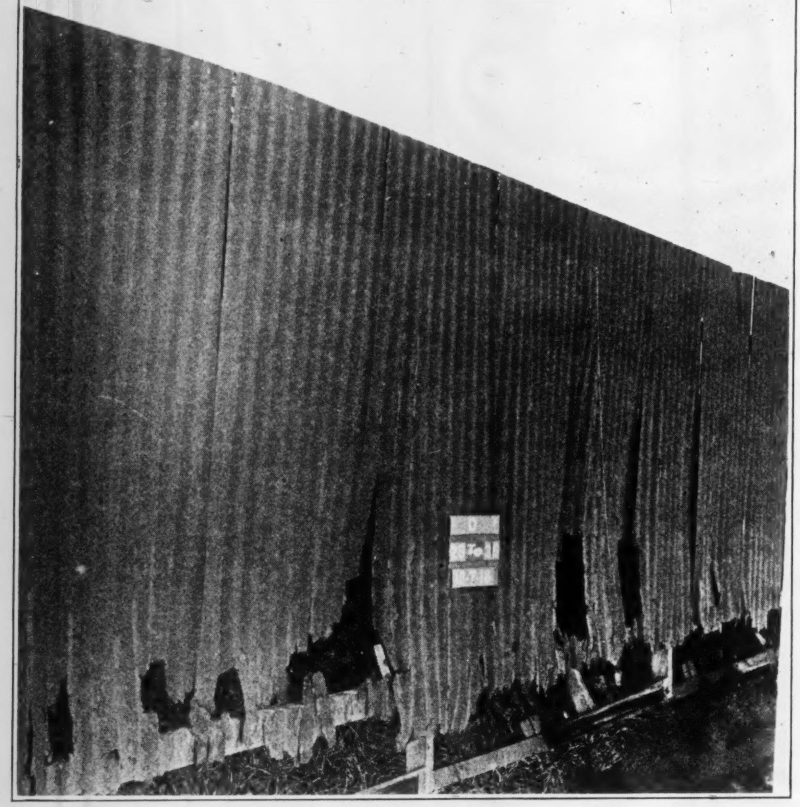

FIG. 10.—PITTSBURGH TESTS.
NO. 22 GAGE LOW COPPER OPEN-HEARTH STEEL.—SERIES A.
Sheets O 29 to 36, inclusive.

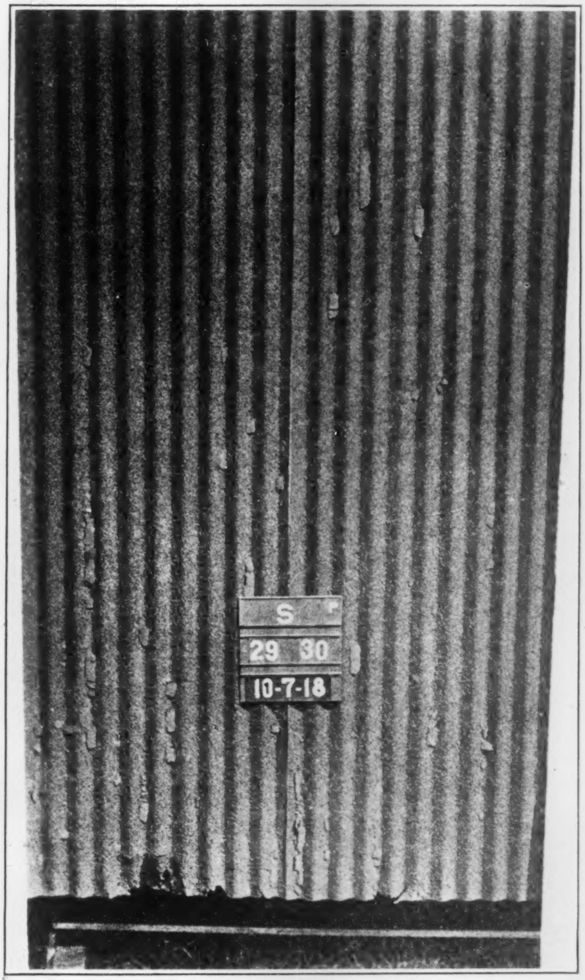

FIG. 11.—PITTSBURGH TESTS.

NO. 22 GAGE LOW-COPPER PURE IRON—SERIES B.

American Rolling Mill Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
S 29........	0.018	0.013	0.005	0.019	....	0.021	Trace
S 30........	0.02	0.011	0.005	0.018	....	0.026	Trace

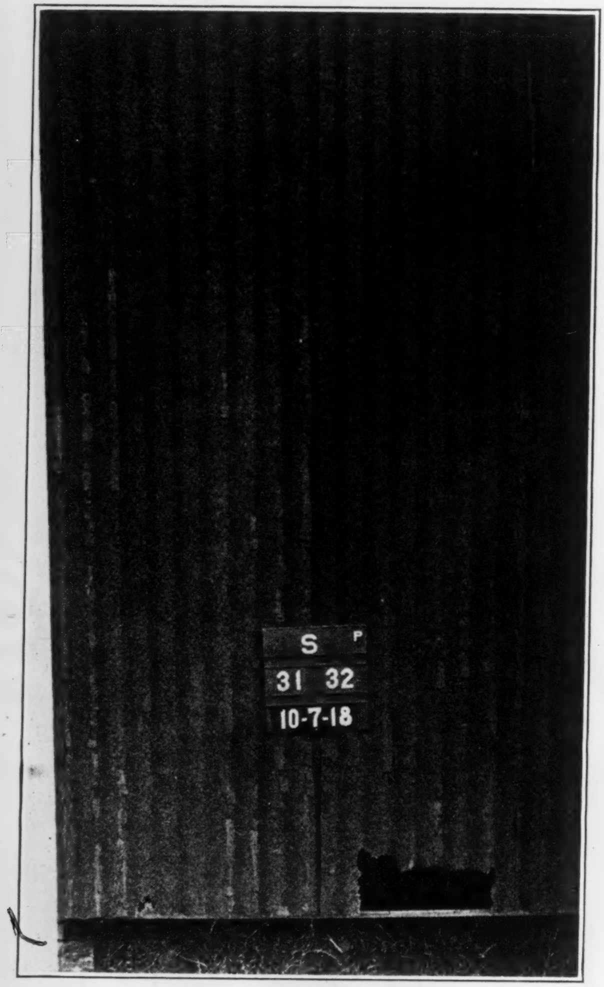

FIG. 12.—PITTSBURGH TESTS.

NO. 22 GAGE LOW-COPPER PURE IRON—SERIES B.

American Rolling Mill Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
S 31........	0.019	0.012	0.005	0.018	....	0.030	Trace
S 32........	0.02	0.018	0.005	0.029	0.001	0.016	None

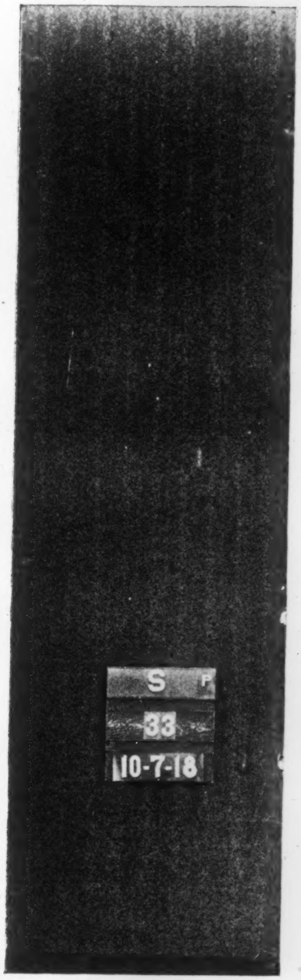

FIG. 13.—PITTSBURGH TESTS.

NO. 22 GAGE LOW-COPPER PURE IRON—SERIES B.

American Rolling Mill Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
S 33........	0.02	0.018	0.003	0.028	....	0.016	None

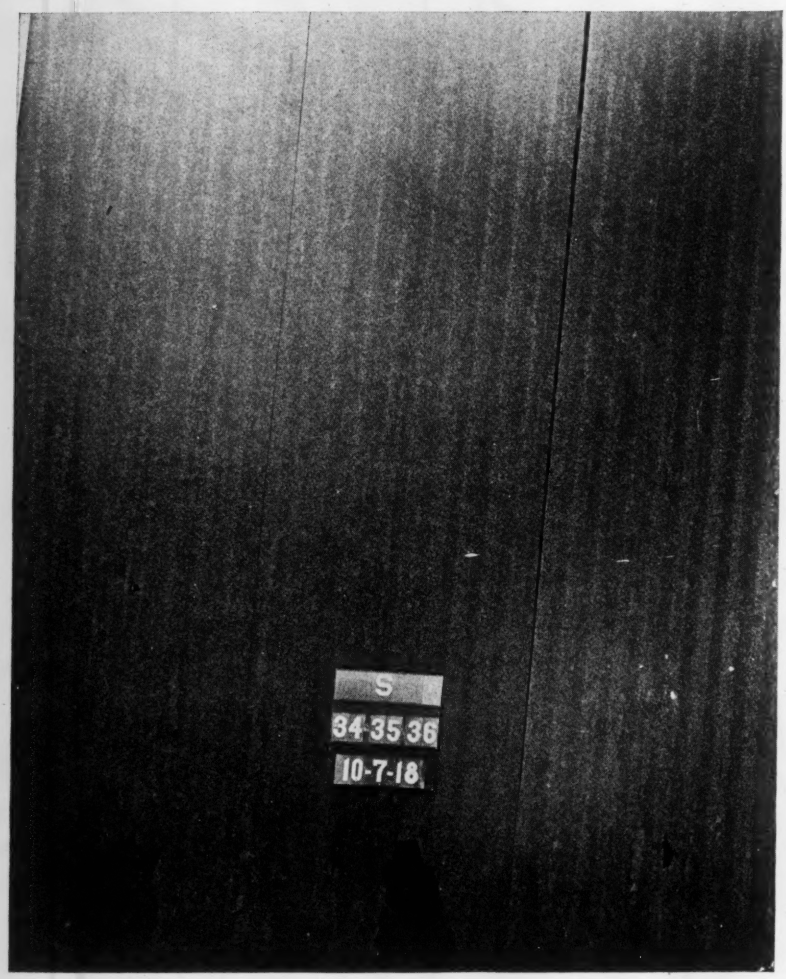

FIG. 14.—PITTSBURGH TESTS.
NO. 22 GAGE LOW-COPPER PURE IRON—SERIES B.
American Rolling Mill Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
S 34........	0.02	0.018	0.004	0.028	....	0.018	None
S 35........	0.02	0.018	0.003	0.024	0.001	0.018	None
S 36........	0.015	0.02	0.006	0.022	0.005	0.03	None

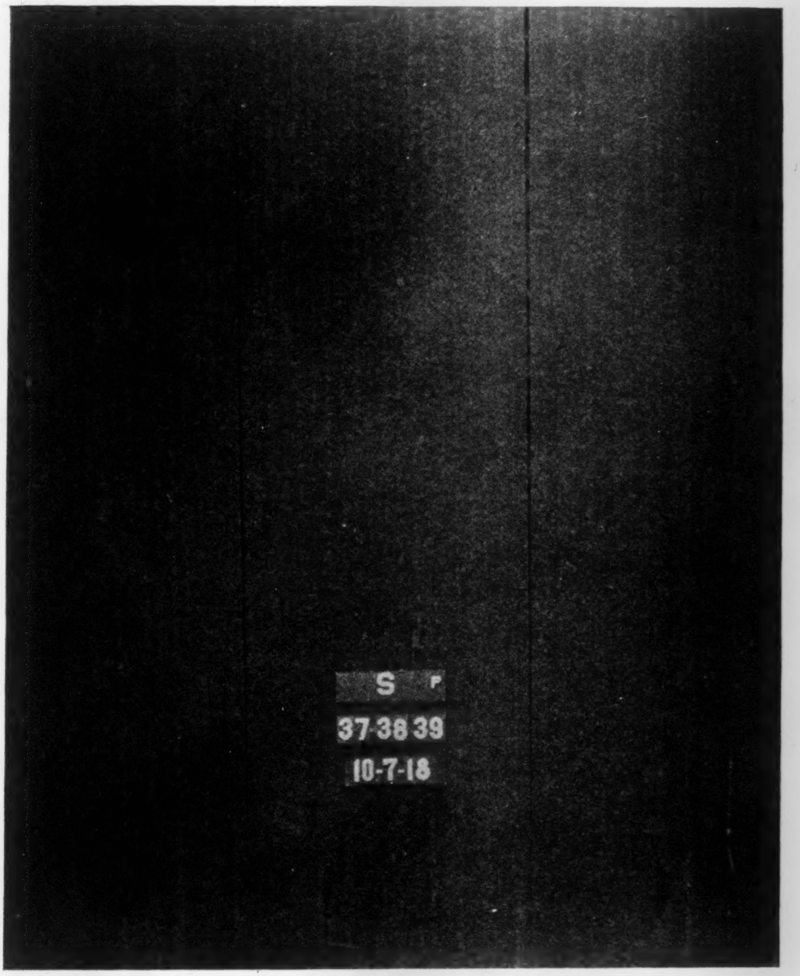

FIG. 15.—PITTSBURGH TESTS.

NO. 22 GAGE LOW-COPPER PURE IRON—SERIES B.

American Rolling Mill Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
S 37........	0.015	0.02	0.004	0.027	0.006	0.024	None
S 38........	0.025	0.02	0.006	0.029	0.005	0.03	None
S 39........	0.015	0.02	0.005	0.027	0.005	0.024	None

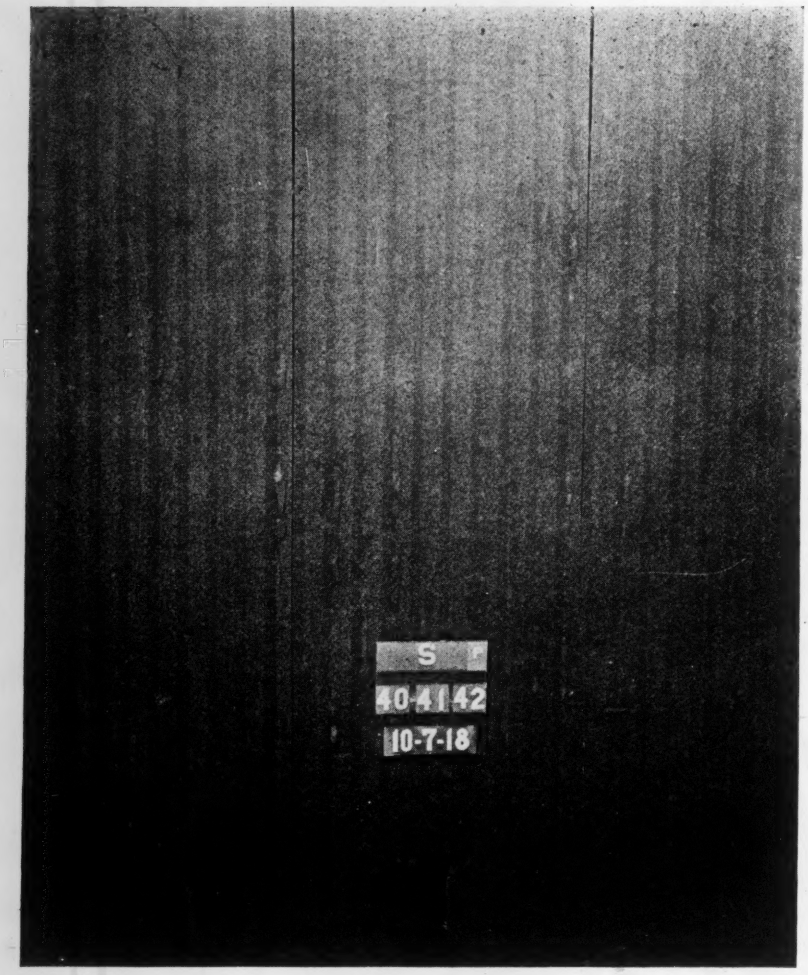

FIG. 16.—PITTSBURGH TESTS.

NO. 22 GAGE LOW-COPPER PURE IRON—SERIES B.

American Rolling Mill Co.

HEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
S 40........	0.01	0.02	0.004	0.029	0.005	0.04	None
S 41........	0.01	0.02	0.005	0.030	0.004	0.03	None
S 42........	0.02	0.02	0.006	0.026	Trace	0.03	None

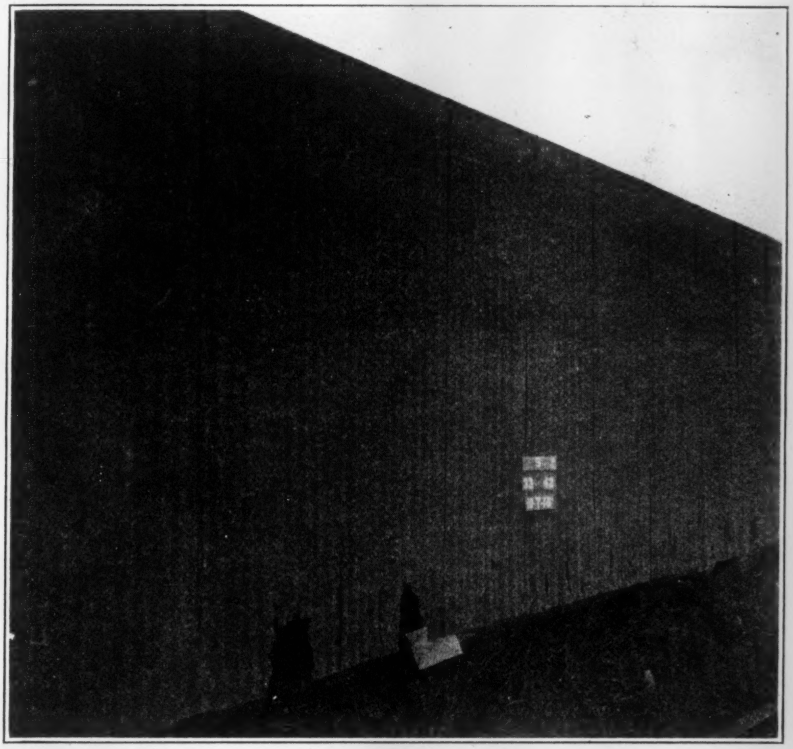

FIG. 17.—PITTSBURGH TESTS.
NO. 22 GAGE LOW-COPPER PURE IRON—SERIES B.
American Rolling Mill Co.
Sheets S 33 to 42, inclusive.

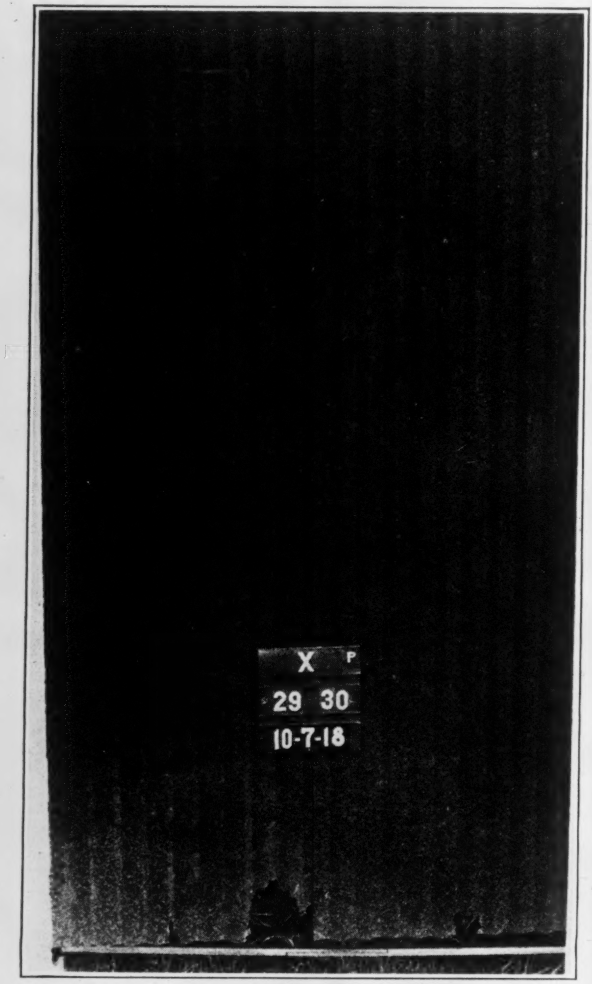

FIG. 18.—PITTSBURGH TESTS.

NO. 22 GAGE LOW-COPPER PURE IRON—SERIES B.

Inland Steel Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
X 29.......	0.023	0.038	0.005	0.029	....	0.026	None
X 30.......	0.018	0.038	0.003	0.028	....	0.026	None

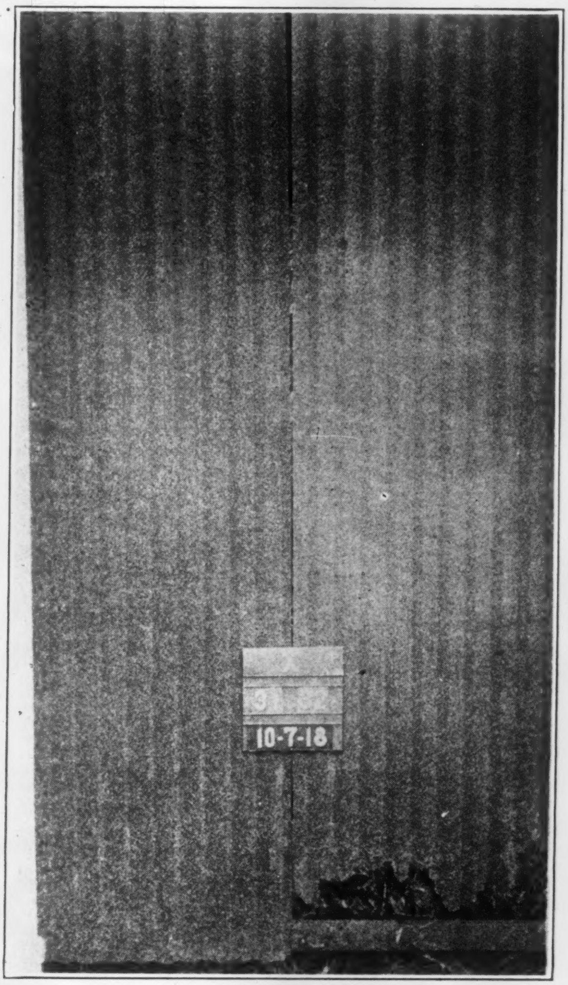

FIG. 19.—PITTSBURGH TESTS.

NO. 22 GAGE LOW-COPPER PURE IRON—SERIES B.

Inland Steel Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
X 31.......	0.02	0.054	0.004	0.031	0.002	0.020	None
X 32.......	0.02	0.054	0.004	0.035	....	0.030	None

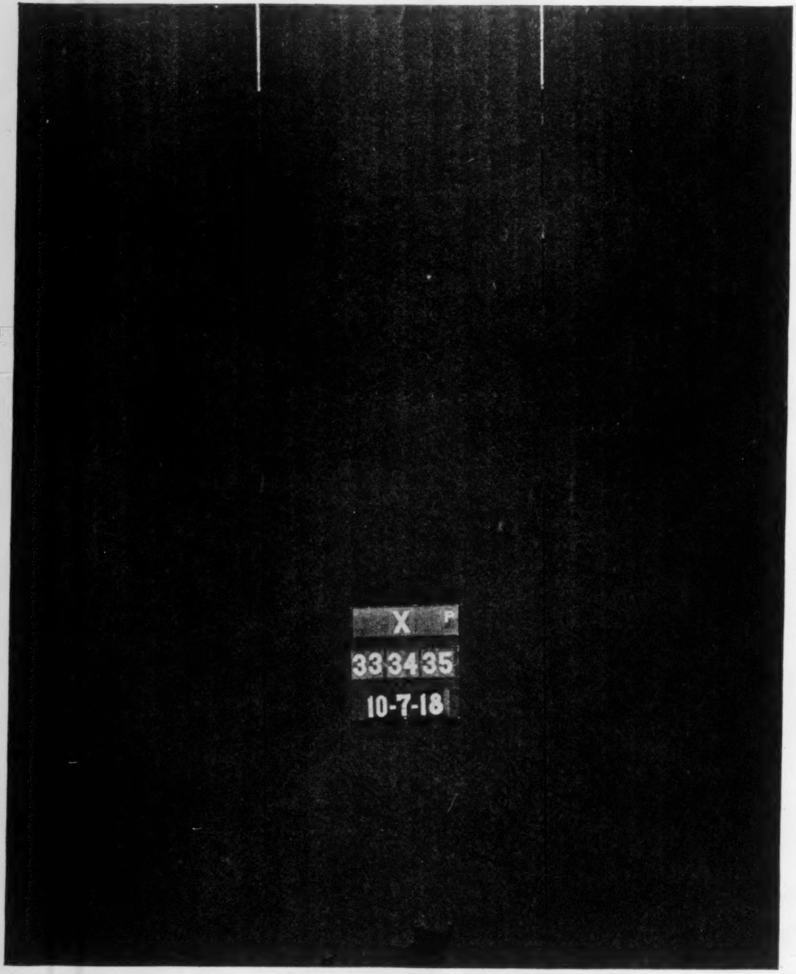

FIG. 20.—PITTSBURGH TESTS.

NO. 22 GAGE LOW-COPPER PURE IRON—SERIES B.

Inland Steel Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
X 33.......	0.02	0.054	0.005	0.030	....	0.020	None
X 34.......	0.02	0.054	0.003	0.031	0.002	0.022	None
X 35.......	0.01	0.08	0.009	0.031	Trace	0.026	None

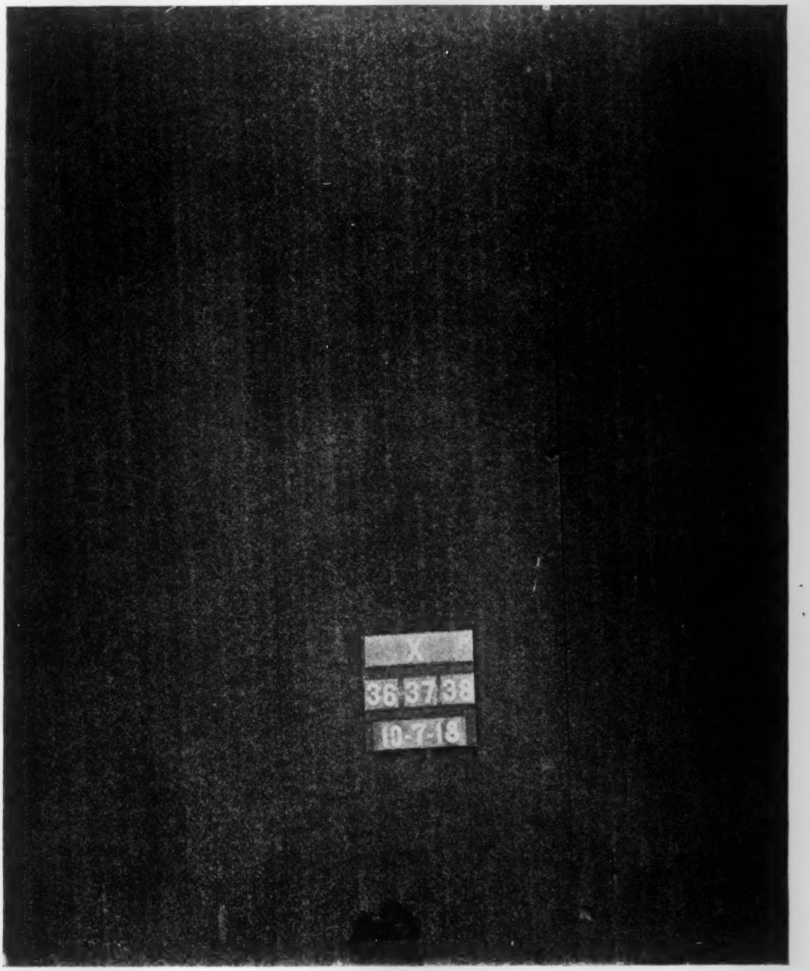

FIG. 21.—PITTSBURGH TESTS.

NO. 22 GAGE LOW-COPPER PURE IRON—SERIES B.

Inland Steel Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
X 36.......	0.02	0.05	0.007	0.029	Trace	0.025	None
X 37.......	0.025	0.08	0.010	0.025	Trace	0.027	None
X 38.......	0.02	0.07	0.008	0.030	Trace	0.025	None

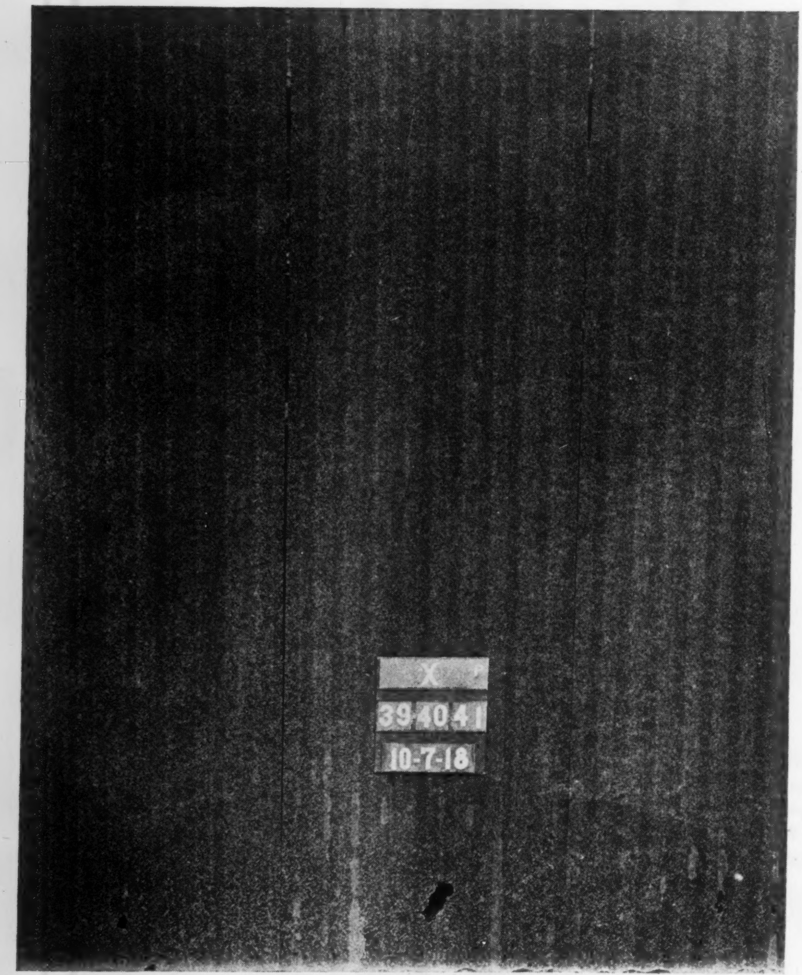

FIG. 22.—PITTSBURGH TESTS.

NO. 22 GAGE LOW-COPPER PURE IRON—SERIES B.

Inland Steel Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
X 39.......	0.005	0.06	0.008	0.029	Trace	0.025	None
X 40.......	0.035	0.06	0.007	0.032	Trace	0.025	None
X 41.......	0.03	0.06	0.007	0.036	Trace	0.025	None

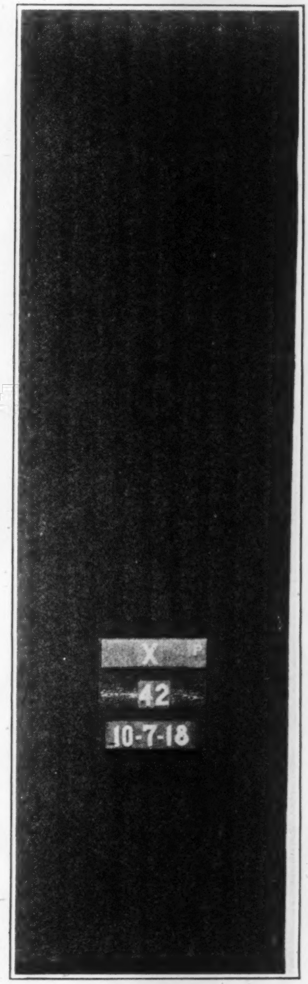

FIG. 23.—PITTSBURGH TESTS.

NO. 22 GAGE LOW-COPPER PURE IRON—SERIES B.

Inland Steel Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
X 42.......	0.03	0.05	0.008	0.031	Trace	0.025	None

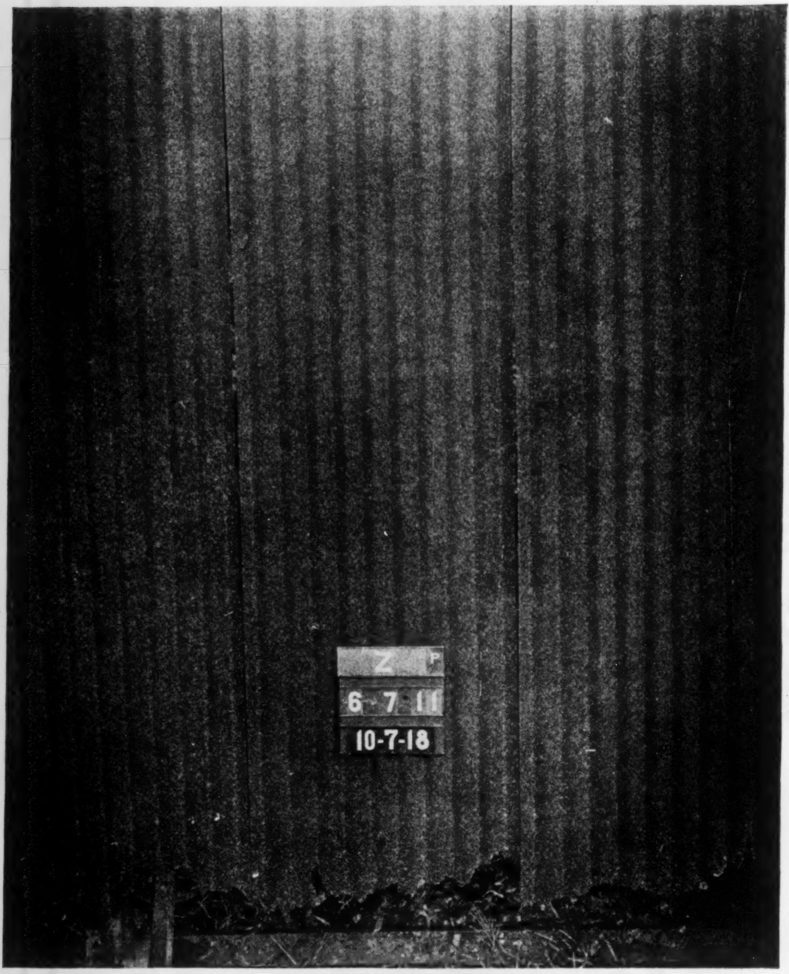

FIG. 24.—PITTSBURGH TESTS.

NO. 22 GAGE BESSEMER STEEL (VARYING COPPER CONTENT)—SERIES B.

Youngstown Sheet and Tube Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
Z 6........	0.045	0.35	0.128	0.045	0.003	0.010	None
Z 7........	0.065	0.35	0.112	0.047	....	0.014	None
Z 11.......	0.055	0.40	0.116	0.052	....	0.014	None

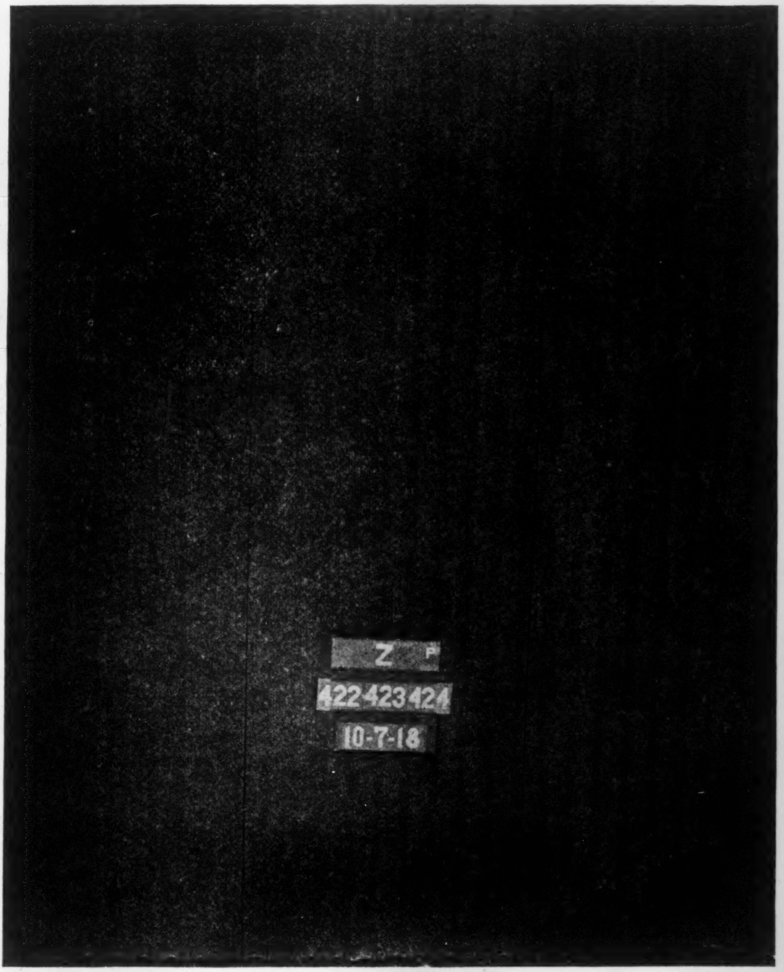

FIG. 25.—PITTSBURGH TESTS.

NO 22 GAGE OPEN-HEARTH STEEL (VARYING COPPER CONTENT)—SERIES B.

Youngstown Sheet and Tube Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
Z 422......	0.090	0.315	0.068	0.043	....	0.019	None
Z 423......	0.105	0.313	0.070	0.045	....	0.016	None
Z 424......	0.11	0.328	0.068	0.043	0.002	0.018	None

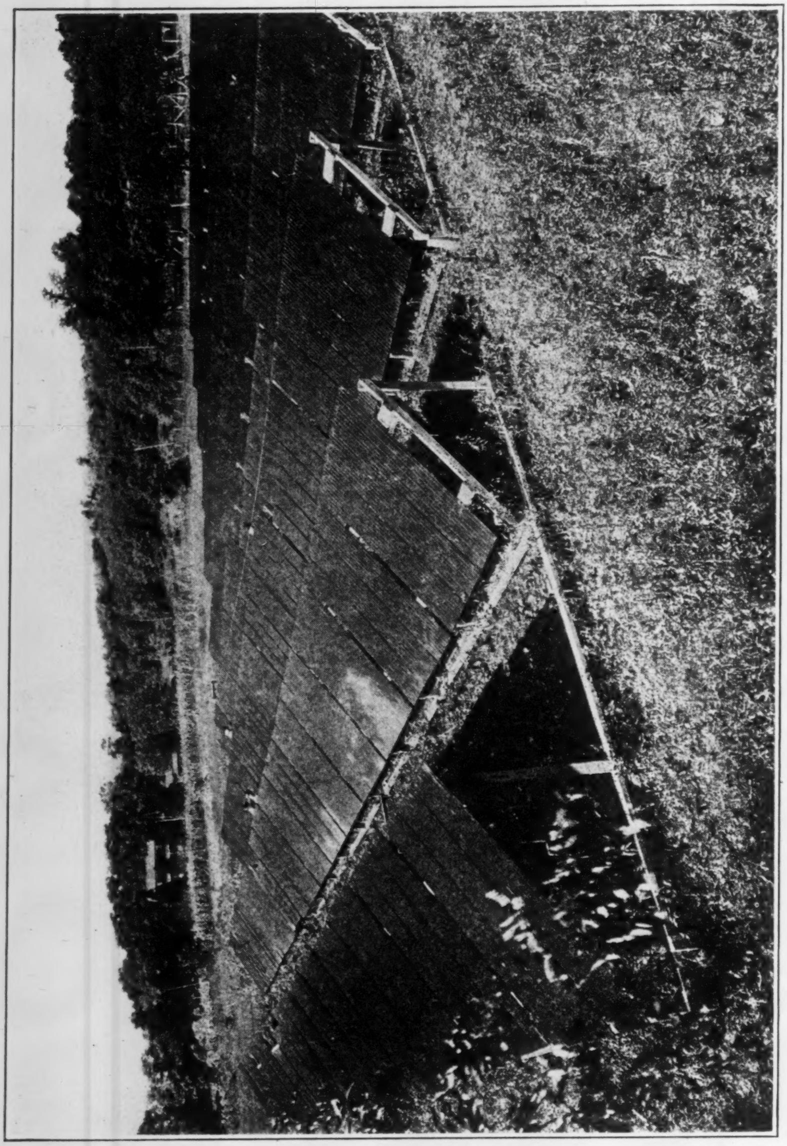

FIG. 26.—ANNAPOLIS TEST RACK.

Sheets Exposed October 17, 1916. Photographed October 8, 1918.

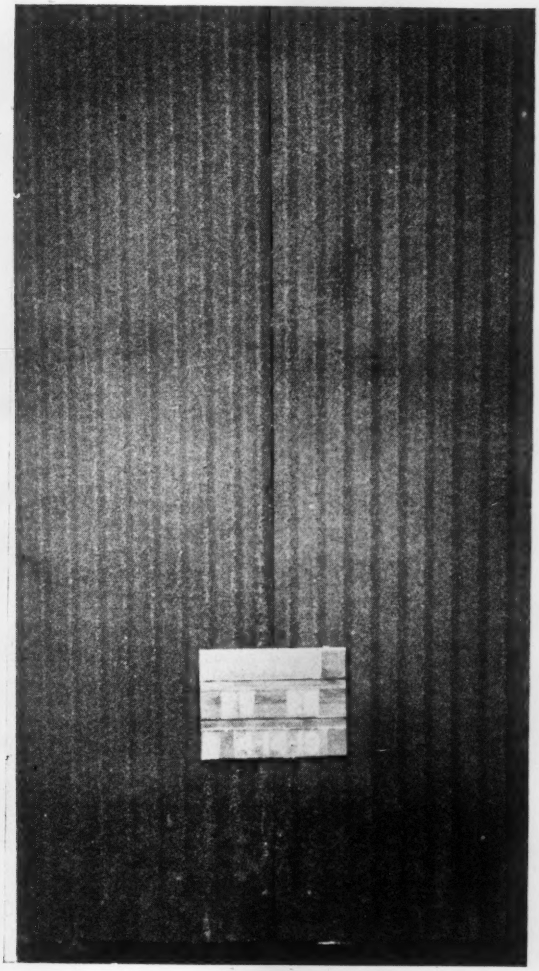

FIG. 27.—PITTSBURGH TESTS.

NO. 16 GAGE BESSEMER STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
AA 25......	0.032	0.40	0.087	0.039	....	0.019	....
AA 26......	0.032	0.40	0.083	0.037	....	0.018	....

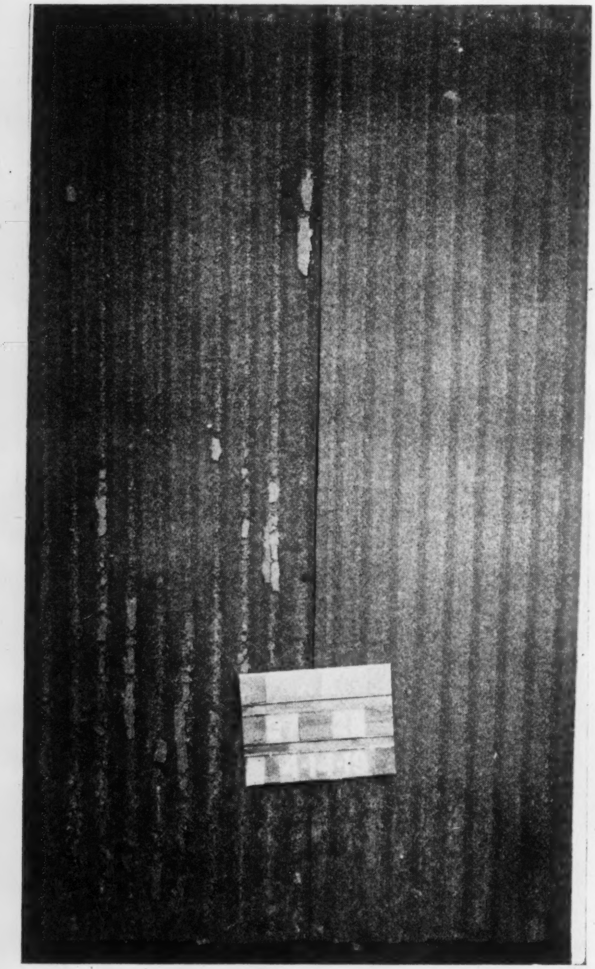

FIG. 28.—PITTSBURGH TESTS.

NO. 16 GAGE BESSEMER STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
AA 27......	0.032	0.39	0.085	0.041	....	0.018	....
AA 28......	0.035	0.40	0.080	0.039	....	0.018	....

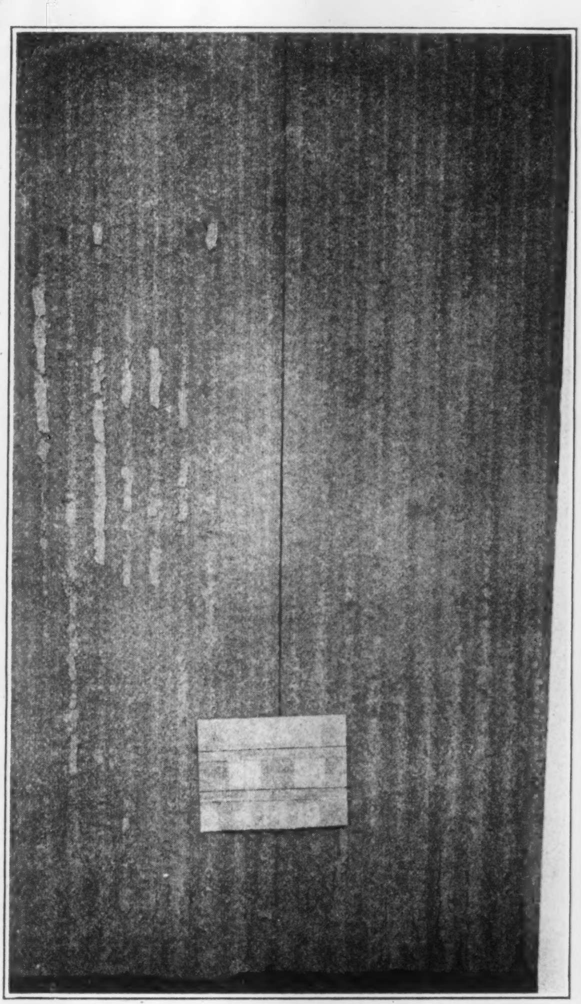

FIG. 29.—PITTSBURGH TESTS.

NO. 16 GAGE BESSEMER STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent,	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
AA 29......	0.035	0.40	0.086	0.040	....	0.016	....
AA 30......	0.035	0.39	0.082	0.040	....	0.018	....

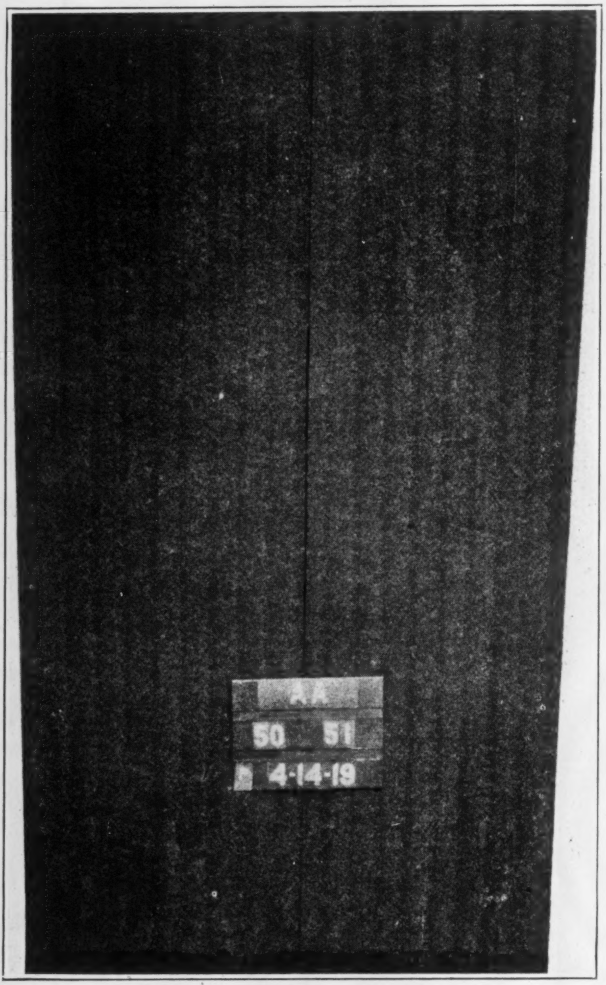

FIG. 30.—PITTSBURGH TESTS.

NO. 16 GAGE BESSEMER STEEL—SERIES A:

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
AA 50......	0.08	0.42	0.093	0.046	....	0.006	....
AA 51......	0.07	0.44	0.085	0.041	0.009	0.008	0.002

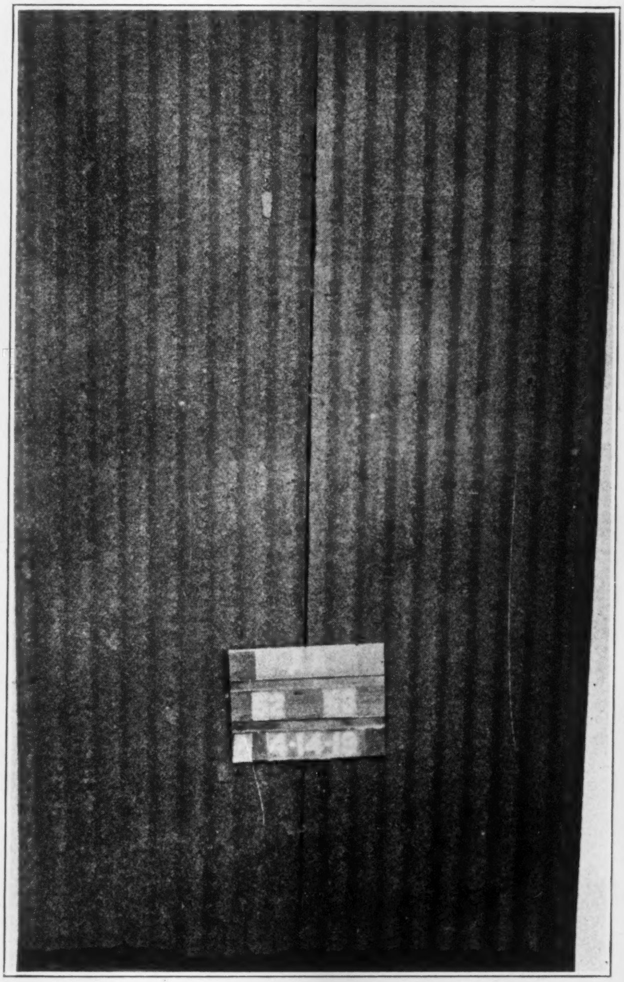

FIG. 31.—PITTSBURGH TESTS.

NO. 16 GAGE BESSEMER STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
AA 52......	0.05	0.44	0.086	0.041	....	0.012	....
AA 53......	0.06	0.42	0.083	0.045	....	0.008	....

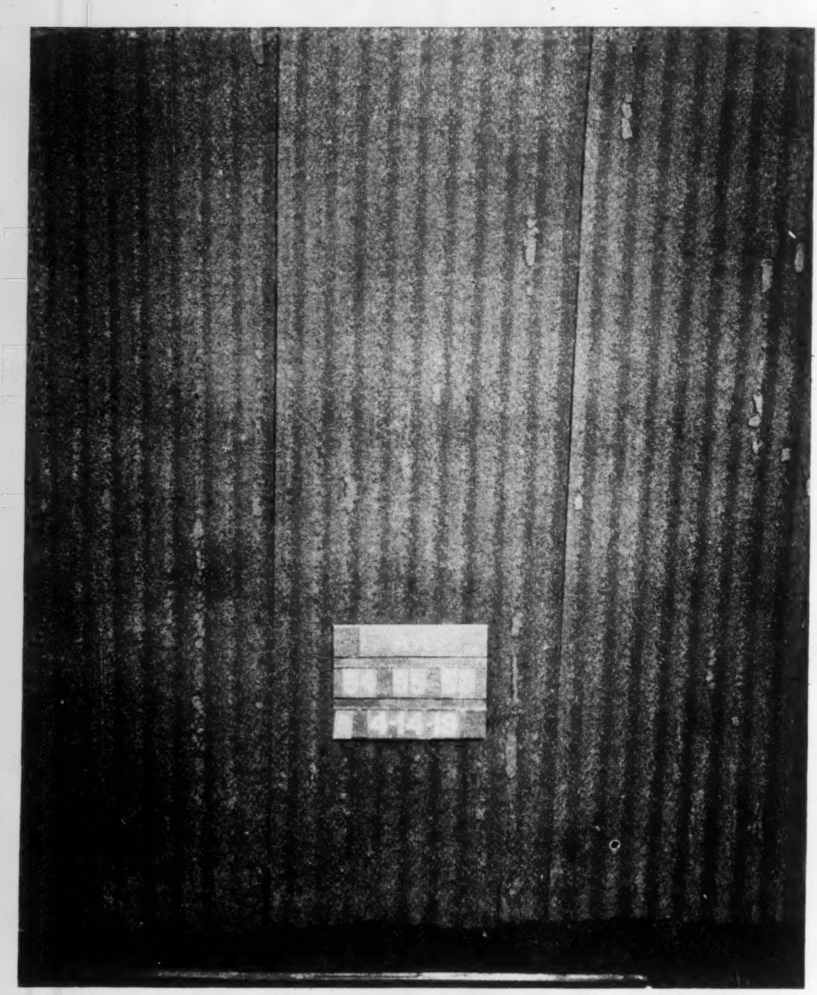

FIG. 32.—PITTSBURGH TESTS.

NO. 16 GAGE BESSEMER STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
AA 54......	0.05	0.42	0.089	0.041	....	0.006	....
AA 55......	0.05	0.41	0.088	0.041	....	0.006	....
AA 56......	0.05	0.42	0.091	0.045	0.009	0.004	....

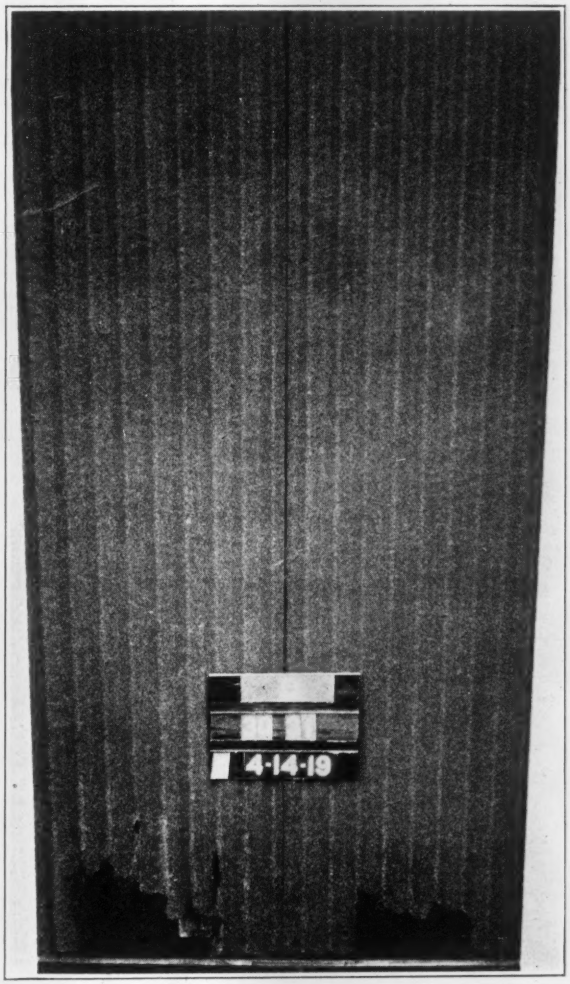

Fig. 33.—Pittsburgh Tests.

No. 22 Gage Low-Copper Pure Iron—Series A.

Sheet.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
D 30.......	0.02	0.05	0.002	0.018	....	0.02	0.02
D 31.......	0.01	0.04	0.002	0.018	....	0.02	0.02

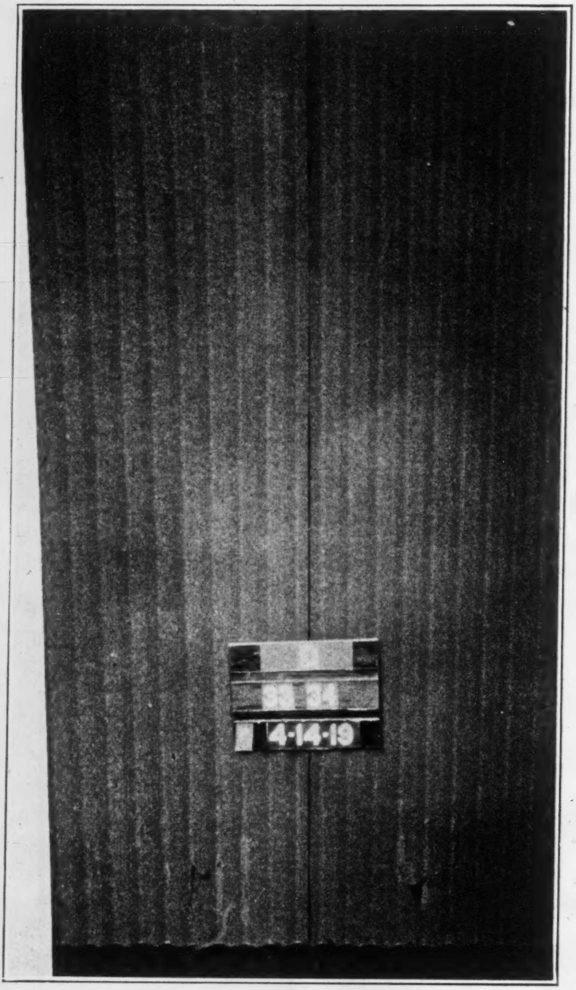

FIG. 34.—PITTSBURGH TESTS.

NO. 22 GAGE LOW-COPPER PURE IRON—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
D 33.......	0.02	0.03	0.004	0.019	Trace	0.027	0.02
D 34.......	0.02	0.02	0.005	0.020	....	0.025	....

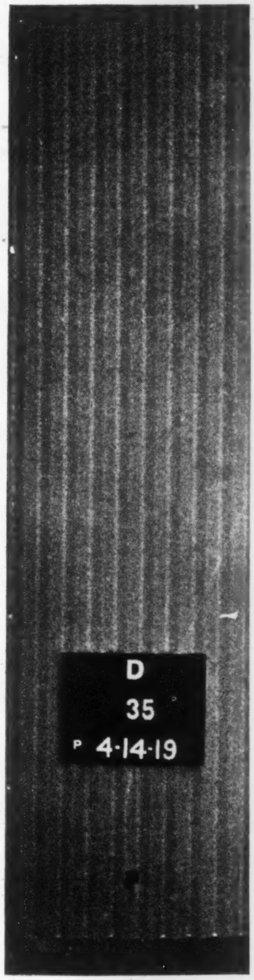

FIG. 35.—PITTSBURGH TESTS.

NO. 22 GAGE LOW-COPPER PURE IRON—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
D 35.......	0.03	0.02	0.004	0.021	....	0.028	....

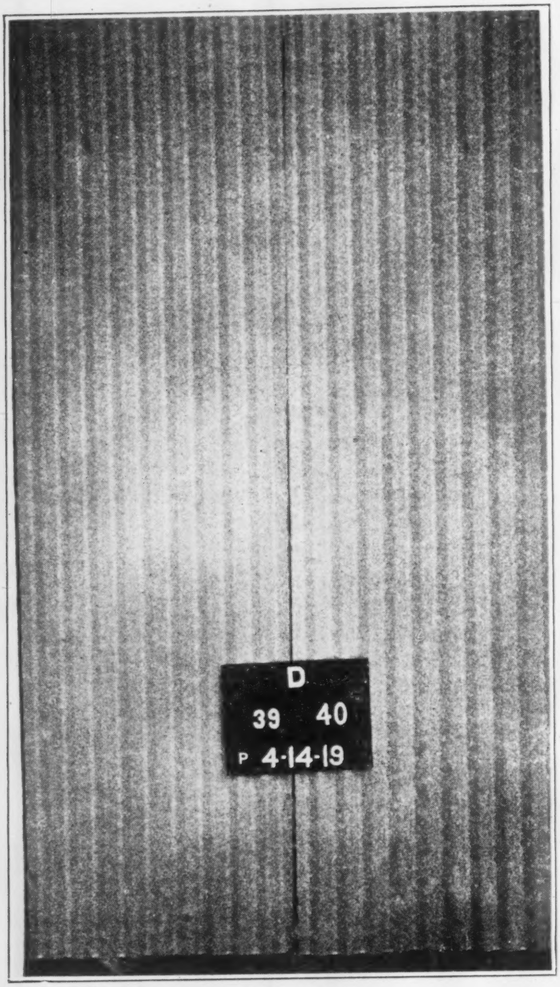

FIG. 36.—PITTSBURGH TESTS.

NO. 22 GAGE LOW-COPPER PURE IRON—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
D 39.......	0.02	0.02	0.004	0.023	....	0.020	....
D 40.......	0.05	0.02	0.003	0.022	....	0.024	....

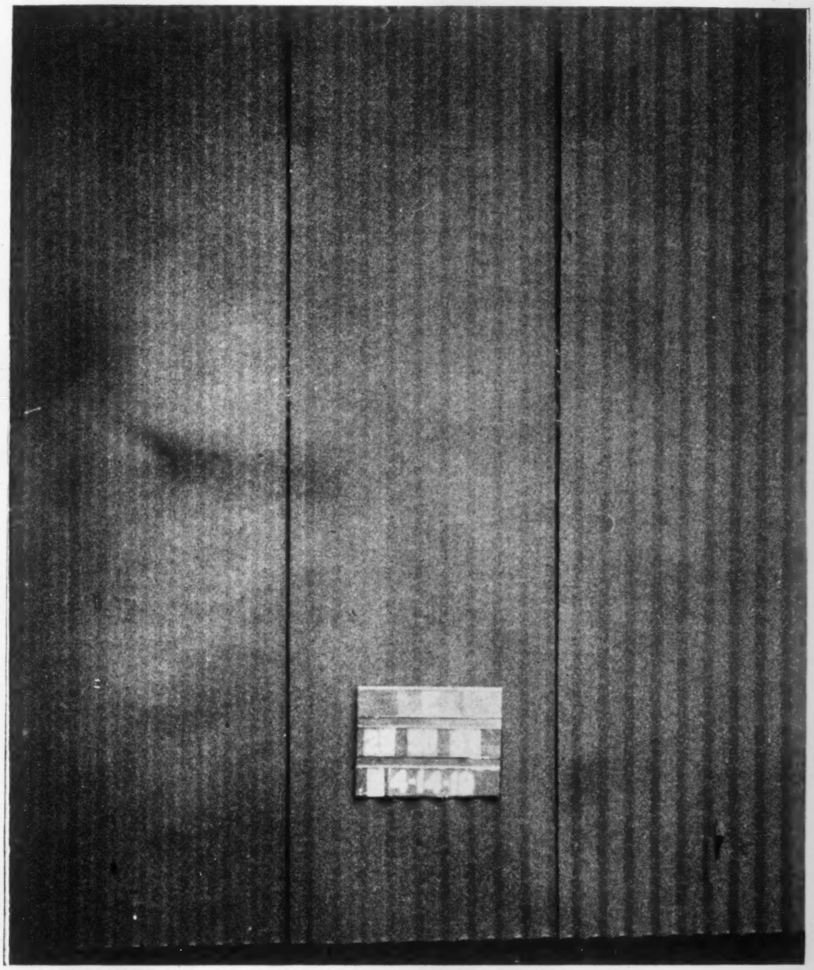

FIG. 37.—PITTSBURGH TESTS.

NO. 22 GAGE PUDDLED IRON—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
E 29.......	0.06	0.02	0.097	0.019	0.022	0.28	0.020
E 30.......	0.03	0.02	0.114	0.021	0.126	0.28	0.025
E 31.......	0.03	0.02	0.104	0.020	0.122	0.31	0.020

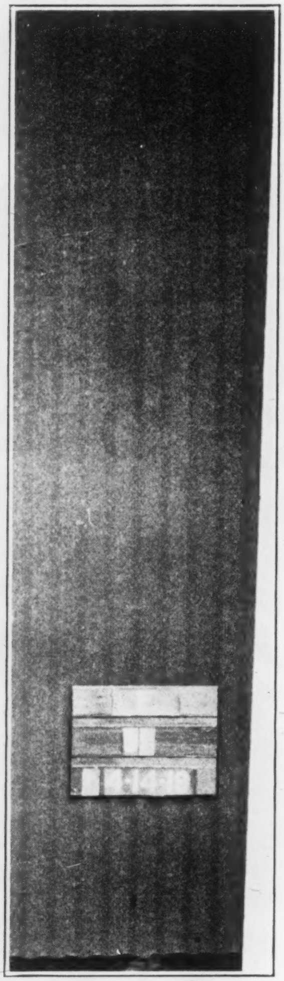

FIG. 38.—PITTSBURGH TESTS.

NO. 22 GAGE PUDDLED IRON—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
E 36.......	0.02	0.02	0.101	0.020	0.141	0.31	0.015

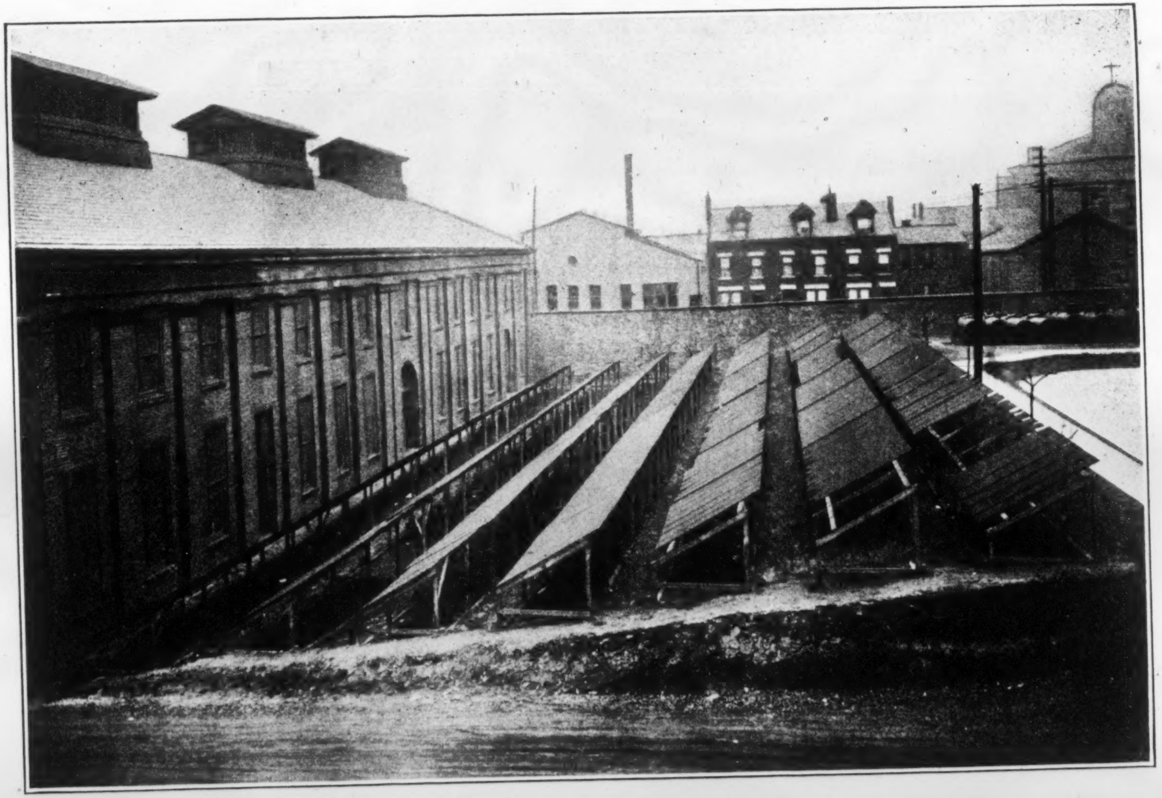

FIG. 39.—PITTSBURGH TEST RACK.

Sheets Exposed December 12, 1916. Photographed April 14, 1919.

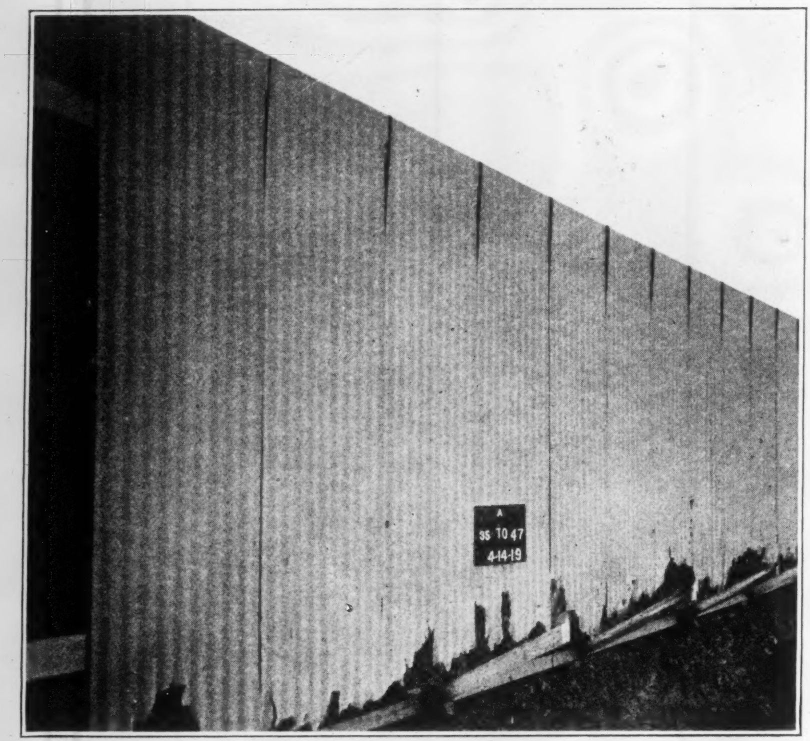

FIG. 40.—PITTSBURGH TESTS.
NO. 22 GAGE BESSEMER STEEL—SERIES A.
Sheets A 35 to 47, inclusive.

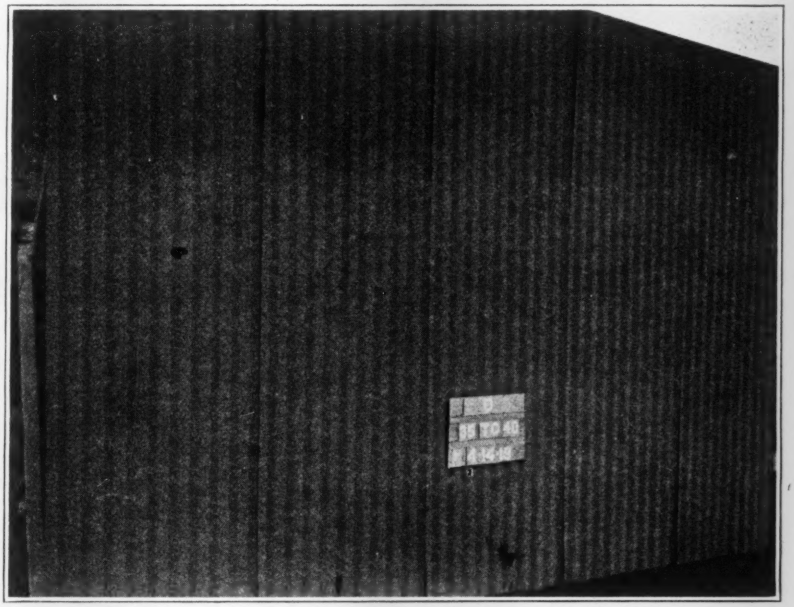
D
35 TO 40
4-14-19

FIG. 41.—PITTSBURGH TESTS.
NO. 22 GAGE LOW-COPPER PURE IRON—SERIES A.
Sheets D 35, 36, 38, 39 and 40.

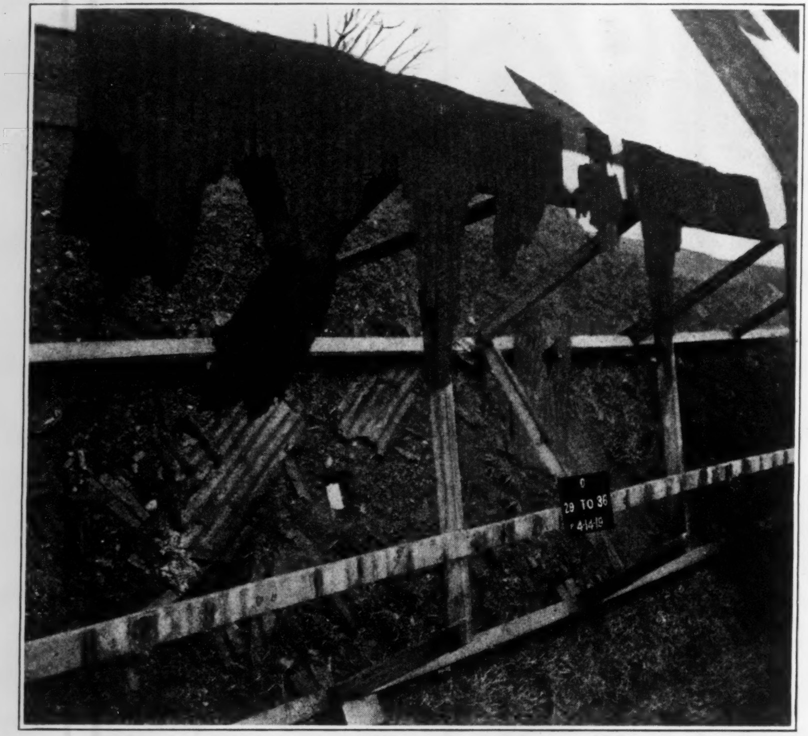

FIG. 42.—PITTSBURGH TESTS.
NO. 22 GAGE LOW-COPPER OPEN-HEARTH STEEL—SERIES A.
Sheets O 29 to 36, inclusive.

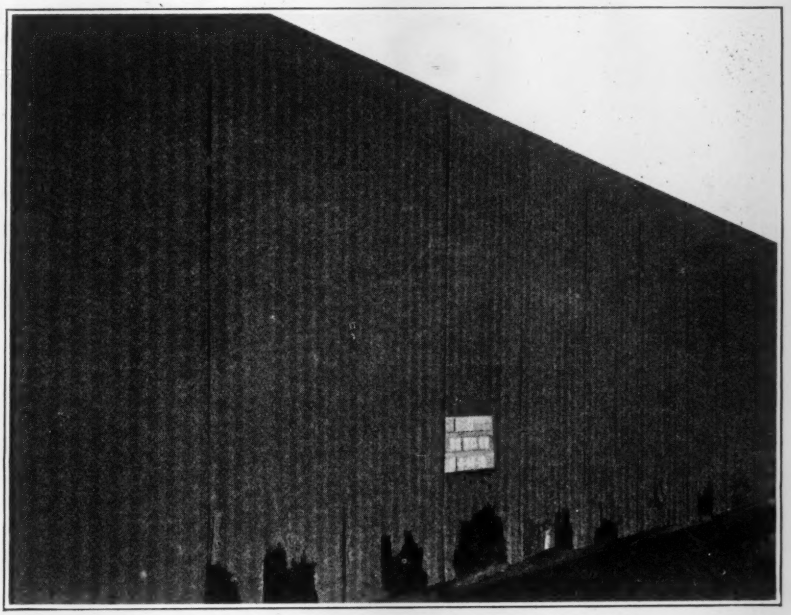

FIG. 43.—PITTSBURGH TESTS.
NO. 22 GAGE LOW-COPPER PURE IRON—SERIES B.
American Rolling Mill Co.
Sheets S 33 to 42, inclusive.

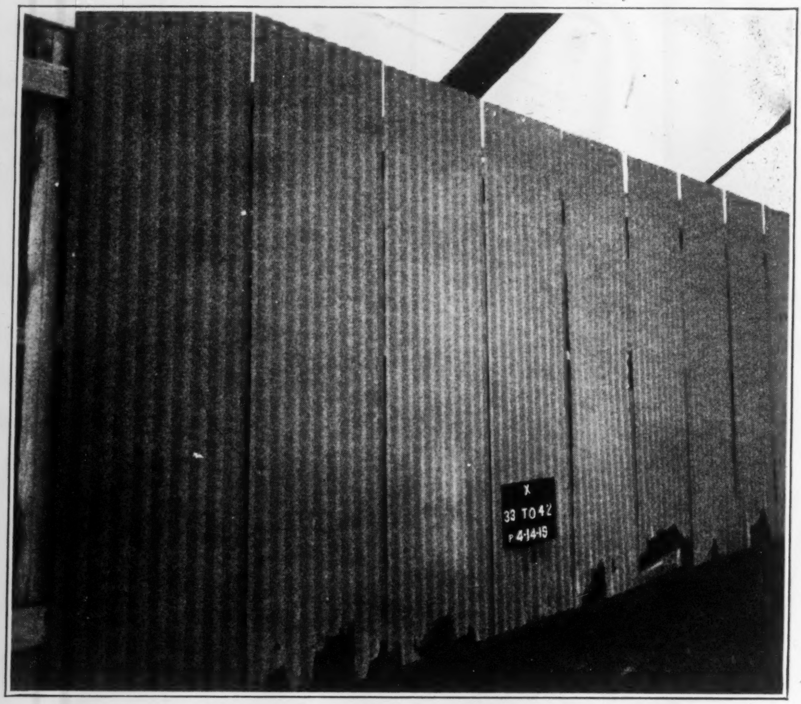

FIG. 44.—PITTSBURGH TESTS.
NO. 22 GAGE LOW-COPPER PURE IRON—SERIES B.
Inland Steel Co.
Sheets X 33 to 42, inclusive.

APPENDIX.

RE-ANALYSES OF DOUBTFUL ELEMENTS IN CORROSION TESTS CONDUCTED UNDER AUSPICES OF COMMITTEE A-5.

To Replace the Percentages Previously Reported in the Tables in the 1916 and 1918 Proceedings.

No. 22 Gage, Bessemer Steel. Series A. Marked *A*.

(*Proceedings*, Vol. XVI, Part I, Table I, p. 155.)

Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.
1	0.020	5	0.016	8	0.015
2	0.019	6	0.018	9	0.017
3	0.017	7	0.018	10	0.018
4	0.016				

No. 22 Gage, Open-hearth Steel. Series A. Marked *B*.

(*Proceedings*, Vol. XVI, Part I, Table III, p. 157.)

Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.
26	0.085	31	0.084	36	0.078
27	0.085	32	0.088	37	0.080
28	0.082	33	0.078	38	0.078
29	0.078	34	0.204	39	0.183
30	0.084	35	0.090		

No. 22 Gage, Low-Copper Pure Iron. Series A. Marked *D*.

(*Proceedings*, Vol. XVI, Part I, Table VII, p. 161.)

Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.
1	0.032	7	0.032	33	0.027
2	0.033	8	0.028	34	0.025
3	0.032	15	0.027	35	0.028
4	0.030	16	0.022	36	0.027
5	0.032	24	0.020	37	0.028
6	0.030				

No. 22 Gage, Open-hearth Steel. Series B. Marked *M*.

(*Proceedings*, Vol. XVIII, Part I, Table I, p. 163.)

Sheet No.	Copper, per cent.	Carbon, per cent.	Manganese, per cent.
15	0.168	0.09	0.370

NO. 22 GAGE, LOW-COPPER OPEN-HEARTH STEEL. SERIES A. MARKED *O*.

(*Proceedings*, Vol. XVIII, Part I, Table II, p. 161.)

Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.
10	0.028	18	0.018	23	0.026
14	0.022	19	0.026	24[a]	0.022
15	0.024	20	0.026	25	0.026
16	0.022	21	0.022	26	0.022
17	0.026	22	0.026	27[b]	0.026

[a] Silicon, 0.218 per cent.
[b] Silicon, 0.236 per cent.

NO. 22 GAGE, ARMCO IRON. SERIES B. MARKED *S*.

(*Proceedings*, Vol. XVIII, Part I, Table III, p. 165.)

Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.
11	0.015	17	0.018	27	0.018
12	0.018	18	0.018	28	0.017
13	0.016	19	0.019	32	0.016
14	0.017	20	0.018	33	0.016
15	0.018	23	0.018	34	0.018
16	0.017	24	0.018	35	0.018

NO. 22 GAGE, VISMERA. SERIES B. MARKED *X*.

(*Proceedings*, Vol. XVIII, Part I, Table XI, p. 173.)

Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.
7	0.028	13	0.026	28	0.027
8	0.030	14	0.026	29	0.026
9	0.028	15	0.028	30	0.026
10	0.030	25	0.026	35	0.026
11[a]	0.030	26	0.026	37	0.027
12	0.026	27	0.025		

[a] Sulfur, 0.049 per cent.

NO. 22 GAGE, BESSEMER STEEL. SERIES B. MARKED *Z*.

(*Proceedings*, Vol. XVIII, Part I, Table XIV, p. 176.)

Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.
1	0.014	109	0.134	209	0.261
2	0.014	110	0.126	213	0.250
3	0.012	111	0.138	214	0.260
4	0.012	112	0.134	301	0.526
5	0.010	113	0.128	303	0.520
6	0.010	202	0.253	305	0.536
7	0.014	204	0.274	306	0.534
11	0.014	206	0.270	308	0.530
101	0.141	207	0.259	310	0.488
102	0.138	208	0.266	314	0.536
108	0.140				

NO. 22 GAGE, OPEN-HEARTH STEEL. SERIES B. MARKED *Z*.

(*Proceedings*, Vol. XVIII, Part I, Table XVI, p. 178.)

Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.
417	0.018	506	0.174	608	0.266
418	0.020	508	0.247	609	0.256
419	0.018	509	0.174	702	0.654
420	0.020	513	0.204	705	0.622
421	0.018	516	0.257	707	0.646
422	0.019	602	0.263	709	0.510
423	0.016	603	0.262	710	0.554
424	0.018	604	0.266	712	0.712
501	0.184	605	0.306	714	0.520
503	0.194	606	0.266	715	0.632
504	0.184	607	0.282		

NO. 16 GAGE, OPEN-HEARTH STEEL. SERIES A. MARKED *BB*.

(*Proceedings*, Vol. XVI, Part I, Table IV, p. 158.)

Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.
19	0.118	23	0.043	27	0.044
20	0.046	24	0.042	28	0.040
21	0.042	25	0.042	29	0.118
22	0.040	26	0.043		

NO. 16 GAGE, LOW-COPPER PURE IRON. SERIES A. MARKED *DD*.

(*Proceedings*, Vol. XVI, Part I, Table VIII, p. 162.)

Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.
1	0.030	8	0.034	20	0.028
2	0.030	9	0.030	22	0.029
3	0.030	10	0.032	23	0.027
4	0.027	11	0.030	53	0.027
5	0.026	12	0.034	55	0.028
6	0.026	16	0.028	57	0.028
7	0.026	19	0.028	58	0.028

NO. 16 GAGE, PUDDLED IRON. SERIES A. MARKED *EE*.

(*Proceedings*, Vol. XVI, Part I, Table X, p. 164.)

Sheet No.	Copper, per cent.
7	0.344

NO. 16 GAGE, OPEN-HEARTH STEEL. SERIES B. MARKED *MM*.

(*Proceedings*, Vol. XVIII, Part I, Table II, p. 164.)

Sheet No.	Copper, per cent.
33	0.042
34	0.043

NO. 16 GAGE, LOW-COPPER OPEN-HEARTH STEEL. SERIES A. MARKED *OO*.

(*Proceedings*, Vol. XVIII, Part I, Table III, p. 162.)

Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.
10	0.038	13	0.038	16	0.038
11	0.038	14	0.034	17	0.042
12	0.038	15	0.042	18	0.046

NO. 16 GAGE, ARMCO IRON. SERIES B. MARKED *SS*.

(*Proceedings*, Vol. XVIII, Part I, Table IV, p. 166.)

Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.
7	0.021	15	0.018	30	0.025
11	0.024	21	0.024	31	0.024
12	0.026	22	0.018	33	0.027
13	0.022	23	0.025	34	0.020
14	0.022				

NO. 16 GAGE, VISMERA. SERIES B. MARKED *XX*.

(*Proceedings*, Vol. XVIII, Part I, Table XII, p. 174.)

Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.
11	0.030	15	0.030	28	0.026
12	0.030	16	0.028	29	0.028
13	0.030	26	0.025	30	0.025
14	0.030	27	0.030		

NO. 16 GAGE, BESSEMER STEEL. SERIES B. MARKED *ZZ–B*.

(*Proceedings*, Vol. XVIII, Part I, Table XV, p. 177.)

Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.
1	0.014	103	0.172	209	0.256
2	0.012	106	0.154	213	0.270
4	0.015	107	0.153	306	0.522
5	0.016	201	0.284	307	0.542
7	0.012	202	0.298	308	0.528
8	0.014	204	0.298	309	0.528
10	0.014	205	0.273	310	0.544
14	0.010	206	0.286	311	0.522
102	0.162	208	0.288	314	0.580

NO. 16 GAGE, OPEN-HEARTH STEEL. SERIES B. MARKED *ZZ–OH*.

(*Proceedings*, Vol. XVIII, Part I, Table XVII, p. 179.)

Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.	Sheet No.	Copper, per cent.
417	0.034	505	0.268	612	0.586
418	0.032	506	0.180	614	0.562
419	0.034	507	0.164	615	0.578
420	0.031	509	0.246	710	0.353
422	0.030	510	0.258	711	0.374
426	0.024	602	0.642	712	0.320
427	0.032	605	0.662	713	0.317
501	0.258	610	0.658	714	0.362
502	0.252	611	0.624	715	0.366
503	0.254				

DISCUSSION.

Mr. Cushman. MR. A. S. CUSHMAN (*presented in written form*).—Weather exposure tests of uncoated sheet metal unquestionably yield information of an instructive character when the results are interpreted in the light of previous experience in test and service. It seems evident from what I am able to show that results of exposure tests made in extremely acid atmospheres such as are encountered in Pittsburgh and in the coke-burning regions of Pennsylvania, are in a class by themselves, and that results obtained by many years' exposure under more average or ordinarily normal conditions do not check with sheet rack exposure tests in Pittsburgh. It was observed in 1917 that the under side of the Pittsburgh test sheets carried a whitish incrustation of a salt which on examination proved to be ferrous sulfate. This is a conclusive demonstration of the unusual acid attack made upon the Pittsburgh test sheets. No other weather exposure tests which have come under my observation have ever shown these salt incrustations. Similar rack tests which have been under observation for varying periods up to eight years at Middletown, Ohio, in a yard which lies between a large open-hearth furnace plant and a canal, do not show salt incrustation, nor do the results in any way tally with or check up the results obtained in a two-year exposure in Pittsburgh.

My own explanation of this is that in Pittsburgh, under the conditions of the tests, we have to do with a particular sort of outdoor acid test. We have observed in Middletown that among the many variables that affect the life of an uncoated rusting sheet out of doors, one very important one is the angle or slope at which the sheet is put out. The steeper the slope, the longer the sheet will last, other things being anywhere near equal. It must be apparent that since rain and fog bring down on to the inclined surface of the sheets very dilute sulfuric acid washed out of the atmosphere, wind and sun will evaporate the water, concentrating the non-volatile sulfuric acid on the uncoated sheet until it is strong enough to etch into or cut the surface. This

Mr. Cushman. action is naturally most severe on the lower or drip-off section of the test piece. Oxygen and water, however, in all out-door exposure tests are sufficiently in excess to cause the hydrolysis leading to the formation of rust. The character of rust formed, depends upon its rate of formation, particularly in the early days, or perhaps months, of exposure.

I am frank to confess that I did not anticipate the results of the uncoated sheet tests at Pittsburgh, for many test sheets of similar types of material which had been under observation for years in Middletown and Washington gave no such results, and it seemed fair to suppose at that time that results obtained in at least one manufacturing center would be confirmed by those obtained under similar test conditions in another. I was aware, of course, that a copper content in steel would enable it to stand an acid test better than a copper-free metal, but not only did I not realize that the Pittsburgh conditions were essentially an acid test but also my mind was affected by the very strong conviction of Committee A-5 that the results of acid tests are unreliable as truly measuring the tendency to natural corrosion, which statement was published as a warning to investigators in the Proceedings of this Society for 1911.

It cannot be gainsaid that under the conditions of the Pittsburgh tests the pure commercial iron sheets have failed, while they have not done so in Middletown under much longer exposure in lighter gages. Moreover, of even more significance is the undoubted fact that large service installations of the same commercial pure iron have stood up and given satisfaction for five years so far, in the close neighborhood of the A. S. T. M. Pittsburgh sheet tests. I have especially in mind a large smoke stack made of pure iron, located only eleven blocks from the Pittsburgh Arsenal, which has given such satisfaction to the owners as compared with the failure of another type of metal, that they are installing another stack of the successful type to replace the failure. The conditions in a stack are, of course, different from those in the sheet test racks, but so are they also different in nearly every kind of service installation. It is at least well known that smoke stacks suffer severely from corrosive attack.

We have collected evidence which appears to point to a new discovery in connection with the rusting of uncoated sheets

Mr. Cushman.

under weather exposure. For a long time we have been puzzled by the fact that sheets of a given type and made from the selfsame heat and ingot did not behave the same way when first exposed in different seasons of the year. It now appears that if uncoated sheets when newly exposed meet a slow rusting attack for the first six months, either on account of environment or on account of comparatively good weather, they have the opportunity to "grain" themselves with a tight granular dehydrated oxide surface which in itself is a natural protective coating and will enable the sheet to show an extraordinary long life out of doors. If, however, the initial attack on the raw uncoated sheet is very severe, as it was in the Pittsburgh test because of the exceedingly acid atmosphere, the grain formed is loose and, instead of being protective, is stimulative to corrosion. In such an acid atmosphere the restraining influence of copper apparently slows down the early acid attack. Moreover, when the tight

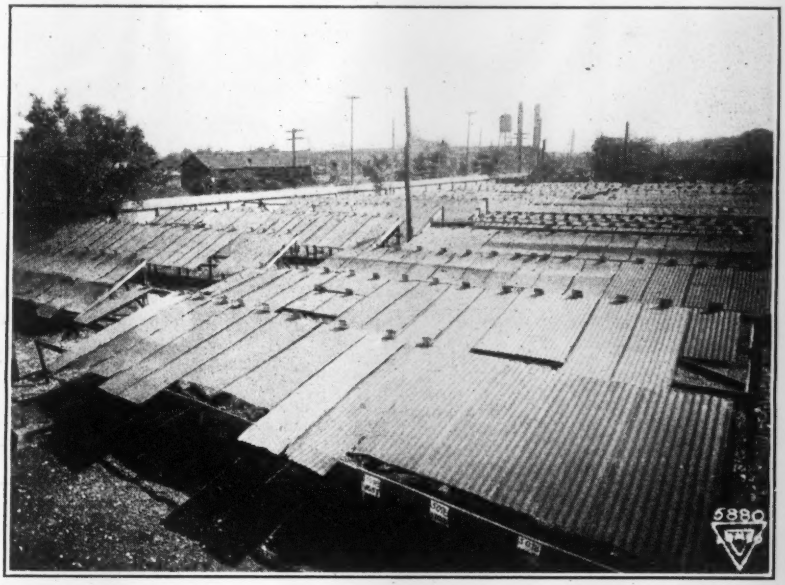

FIG. 1.—Sheets in Test Yard of the American Rolling Mill Co. at Middletown, Ohio.

Mr. Cushman. grain surface of a comparatively slow rusting sheet is removed, it has been found to be more magnetic than the oxide coating from a sheet that has rusted rapidly. Apparently the more magnetic the oxide formed, the more basic and protective it is to the underlying metal. This observation also explains the much discussed relation of the color of the rust surface to the life of the rusting sheet. The claim has often been made by investigators that the darker the rust the longer the uncoated sheet will last before failure occurs, and heretofore there has been no explanation of this observation.

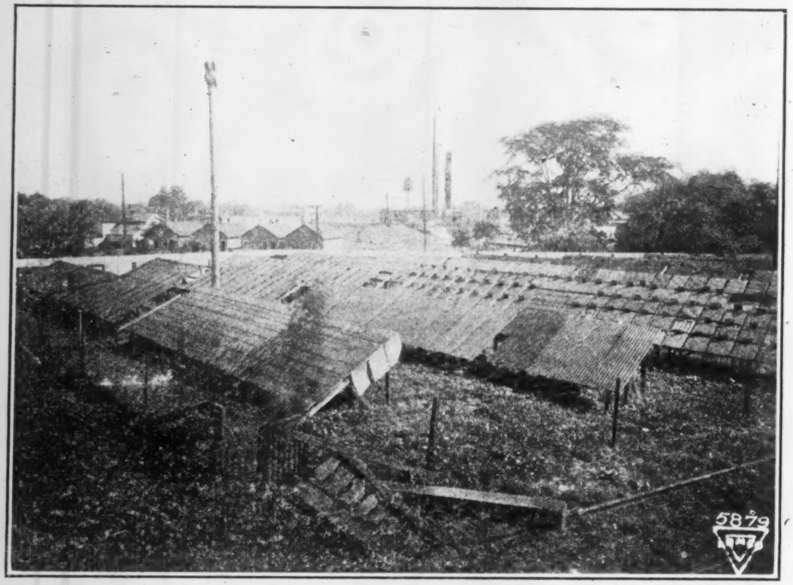

Fig. 2.—Sheets in a Second Test Yard of the American Rolling Mill Co. at Middletown, Ohio.

Further research is needed to verify and substantiate the theory set forth above, but it would appear to furnish a fair explanation of some of the many inconsistencies noted in outdoor exposure tests. Iron and steel coated with other metals or with paint do not get the opportunity to "grain," as suggested above, and therefore outdoor tests of uncoated sheets are no

Mr. Cushman.

criterion of the results obtained under actual service conditions. The theory explains many of the inconsistencies observed in many years of outdoor testing in Middletown and also explains why a material that has given excellent results under test in other places failed under the acid test of the Pittsburgh atmosphere.

That similar sheets exposed at Pittsburgh and at Middletown, Ohio, do not check each other, is shown in the accompanying photographs. It will be remembered that the Society's tests at Pittsburgh consist of two groups—A and B. Group A sheets were purchased in the open market. Group B sheets were specially manufactured for introduction into the test. The commercially pure iron sheets in Group B represented an endeavor to make a heat with the absolute minimum possible copper content. As a matter of fact, however, with the best endeavor the Group B sheets actually came out with practically the same copper content as was found to exist in the Group A

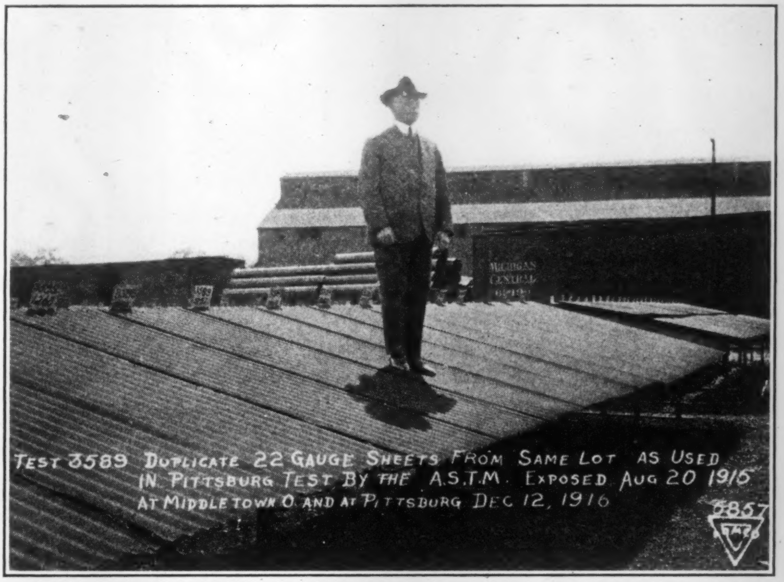
TEST 3589 DUPLICATE 22 GAUGE SHEETS FROM SAME LOT AS USED IN PITTSBURG TEST BY THE A.S.T.M. EXPOSED AUG 20 1915 AT MIDDLETOWN O. AND AT PITTSBURG DEC 12, 1916
5857

FIG. 3.—No. 22 Gage Sheets of the Same Lots as Used in the A. S. T. M. Test at Pittsburgh. Exposed August, 1915; Photographed June 15, 1919.

Mr. Cushman. sheets—about 0.02 per cent. As soon as the Group B sheets were manufactured, some were sent to Committee A-5 for analysis and to be prepared for exposure on the test racks. Some of the sheets were, however, immediately exposed on test racks at Middletown. As far as length of exposure is concerned, therefore, the B sheets exposed in Middletown are nearly a year older than the sister sheets exposed in Pittsburgh. It has already been reported that the Group B sheets of commercially pure iron at Pittsburgh have largely failed. That this is not the case at Middletown is clearly shown by the illustration (Fig. 3). The illustrations in Figs. 1 and 2 are included in order to show the general scope of the Middletown tests which are quite as exhaustive as any that have yet been reported by anyone. It is very evident, therefore, that exposure to atmospheric conditions of uncoated sheet metal does not lead to the same results in different atmospheres. It would appear that the interpretation of the results of such tests is an important matter, and that it is not safe to draw sweeping conclusions based upon the results obtained under any given set of conditions as applying to the general conditions of corrosion resistance.

Mr. Buck. MR. D. M. BUCK (*by letter*).—I have read, with particular interest, Mr. Cushman's discussion of the report of Committee A-5.

The evidence which Mr. Cushman offers in the form of photographs of commercially pure iron sheets, Series "B," manufactured by the American Rolling Mill Co., proves nothing except that the atmospheric conditions at Middletown are not so severe as those in Pittsburgh. In the tests at Annapolis and Fort Sheridan, Committee A-5 has similar sheets which, at the time of the last inspection, seemed to be in about the same condition as the sheets shown by Mr. Cushman which were exposed at Middletown; the differences being that at Annapolis and Fort Sheridan, the committee also has sheets representative of the other types of material, and at some time in the future will be able to draw comparisons between the relative corrosion rates of all of these materials. Such comparisons are impossible in Mr. Cushman's test.

By examining the official report it will be noted that, in the opinion of the committee as a whole, distinct differences in the texture of the rust, adherence and color of the rust film have been observed at Annapolis and Fort Sheridan, and that these differ-

Mr. Buck. ences correspond very closely with the condition of the Pittsburgh test in the early stages.

I have conducted extensive series of corrosion tests in the air of an industrial district, as well as in pure country air and in salt air, and it has been my invariable experience that, although the corrosion rate of all materials is slower in the pure air and salt air, the order of failure of the sheets has been the same.

Mr. Cushman stated that he has discovered that, if the sheets in the early period of exposure meet with a slow rusting attack, "they have the opportunity to 'grain' themselves with a tight granular dehydrated oxide surface which in itself is a natural protective coating and will enable the sheet to show an extraordinarily long life out of doors," and that, on the other hand, in severe weather the grain is loose and is stimulative to corrosion. This is very interesting from a scientific point of view, but it is obviously not of practical interest, for the reason that the weather conditions are not under our control. Furthermore, at the Pittsburgh test, where, according to Mr. Cushman's statement, the initial attack is very severe, the copper steel and copper-bearing pure iron sheets grained themselves with this same tight oxide surface, notwithstanding the extremely severe conditions; whereas on ordinary steels and low-copper pure irons, the oxide film was loose and apparently stimulative to corrosion. This tightly adherent, dark-colored film is, according to the writer's observations, characteristic of copper steels under all atmospheric conditions irrespective of whether the initial conditions are severe or otherwise, and the results at the three different locations of the committee's tests seem to bear out this statement.

It will be interesting to observe future reports of Committee A-5, which will give the order of failure of the different panels at the other two locations, that is, Annapolis and Fort Sheridan.

Mr. Voorhees. MR. S. S. VOORHEES (*Chairman of Committee A-5—by letter*).—Mr. Cushman states that the tests at Middletown do not bear out those at Pittsburgh. We have two other exposure tests, one at Fort Sheridan, Ill., and one at Annapolis, Md.; both rural conditions; one near a large body of fresh water and the other near salt water. The committee has been careful to draw conclusions only from facts obtained. The two other exposure tests are in progress and the results they show will be made the subject of future reports to this Society.

REPORT OF COMMITTEE A-7

ON

MALLEABLE CASTINGS.

Committee A-7 was organized last year at the time of the annual meeting of the Society and proposed Tentative Standard Specifications for Malleable Castings (A 75–18 T) which were accepted by the Society. These tentative specifications "cover malleable castings for railroad, motor vehicle, agricultural implement, and general machinery purposes." During the year two criticisms were made of the specifications. One was that castings do not show as high tensile strength and elongation as the test bars. The other was that iron made to these specifications was difficult to machine, and the proposal was made that another specification be gotten out to cover castings where machining qualities are a prime requisite.

At a meeting of the committee held in April these criticisms were considered. It was recognized that in steel, alloy, or gray-iron castings tests taken from the castings will not, as a general thing, show as high tensile strength and elongation as the test bars from the same metal. A sub-committee was appointed to obtain data on the relation of tests from bars and from castings, and to report their findings.

In answer to the other criticism it was pointed out that a number of foundries making castings to the present tentative specifications are having no difficulty in regard to the machining quality of the castings. The same sub-committee appointed to get information on the relation of tests of castings to tests of bars, was asked to look into the necessity of separate specifications for malleable iron where good machining qualities are required.

At the meeting of the committee it was unanimously voted to recommend to the Society that the Tentative Specifications for Malleable Castings (A 75–18 T)[1] be referred to letter ballot of the Society for adoption as standard, and that, if adopted, the new standard supersede the present Standard Specifications for Malleable-Iron Castings (A 47–15).[1] The result of the letter ballot vote of the committee on this recommendation is as follows: affirmative, 18; negative, 1; not voting, 1; total, 20.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part I, p. 464 (1918).

It has been suggested that the committee get up specifications for malleable-iron unions and pipe fittings in general. The secretary canvassed the situation, writing to all the firms doing such work, but found no demand for specifications.

This report has been submitted to letter ballot of the committee, which consists of 20 members, of whom 18 have voted affirmatively, 1 negatively, and 1 has refrained from voting.

Respectfully submitted on behalf of the committee,

H. E. DILLER,
Chairman.

ENRIQUE TOUCEDA,
Secretary.

EDITORIAL NOTE.

The Tentative Specifications for Malleable Castings referred to in this report were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1919, and appear in the Supplementary Pamphlet of A.S.T.M. Standards Adopted in 1919.

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[1] 1918 Book of A.S.T.M. Standards.

REPORT OF COMMITTEE B-1

ON

COPPER WIRE.

In previous reports mention has been made of work undertaken by the committee to develop specifications for tinned copper wire. The committee feels that the work has progressed to the point where the formulation of tentative specifications is in order and they have accordingly prepared specifications which are now offered to the Society for approval as tentative.

The principal difficulty in preparing such specifications has been the development of a satisfactory test to determine the efficiency of the tin coating. The object of the tin coating is principally to protect the copper wire against attack by the sulfur in the rubber insulation applied over tinned copper. A cycle test in which the wire is immersed, first, in a solution designed to remove the tin and second, in a solution designed to indicate the exposure of the copper by such removal, has been commonly used for this purpose, and the attempt has generally been made to make such a test quantitative by varying the number of cycles according to the cross-section or diameter of the wire tested. The experiments which have been conducted by the members of Committee B-1 indicate that the tests should not be applied in any quantitative sense: first, because demand for a large number of cycles is equivalent to a demand for a heavy coating of tin, which, for reasons which will appear later, is undesirable; second, because the actual thickness of the coating of tin is substantially independent of the diameter of the wire, but the tendency is for the wires of smaller diameter to carry a relatively heavier coat than coarse wire.

What is actually desired in tinned wire is a thin continuous coat of tin which will protect the copper against attack by sulfur in the rubber insulation. The tin coat, as was shown in a paper by G. G. Grower on "Electrolytic Determination of Tin on Tinned Copper Wire,"[1] consists of an outer layer of pure tin and an inner layer of a tin-copper alloy. This alloy is in itself harder and more brittle than either the tin or the copper; therefore this layer should be as thin as possible. Practical conditions in tinning wire require that the temperature be controlled very accurately and that the wire move through the bath at a uniform rate, and that the surplus tin be wiped off, in order that the final coat may be smooth and fall within the limits to accuracy in gage which are specified. Both the tin and the tin-copper alloy are higher in electrical resistance than copper, therefore it is essential that the tin coating be as thin as possible to prevent undue increase in resistance of the wire. Furthermore, the production of a heavy coat means an increase in thickness of the alloy coat, which, because brittle, is apt to crack during handling and therefore break the continuity of the coat.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVII, Part II, p. 129 (1917).

For all these reasons the committee has been forced to the decision that the use of the chemical cycle test in a quantitative sense is wrong, but that the test is useful in a qualitative sense to determine the continuity of the coat. The committee has therefore departed from precedent in applying this test and now applies it in a qualitative sense only, and requires two cycles for all sizes of wire. One cycle would be sufficient to detect any actual break in continuity of coat, but might not disclose a thin spot, which, however, would be detected by the second cycle.

The tentative specifications offered cover only tinned soft or annealed copper wire. The use of tinned medium hard copper wire is almost unknown and the commercial use of tinned hard-drawn copper wire is limited. The committee will have the matter in hand to draft specifications covering tinned hard-drawn copper wire, if and when the commercial use of such material makes specifications desirable.

The Standard Specifications for Bare Concentric-Lay Copper Cable (B 8-16)[1] will later require modifications so as to include copper cable made from tinned wire and these modifications will be reported after the tentative specifications for tinned soft copper wire have stood for a year or two.

The proposed Tentative Specifications for Tinned Soft or Annealed Copper Wire for Rubber Insulation are appended to this report[1] and are offered for publication by the Society as tentative.

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[1] 1918 Book of A.S.T.M. Standards.

This report has been submitted to letter ballot of the committee, which consists of 10 members, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

J. A. CAPP,
Chairman.

EDITORIAL NOTE.

The proposed Tentative Specifications for Tinned Soft or Annealed Copper Wire for Rubber Insulation referred to in this report were accepted for publication as tentative and appear on pages 503–508.

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[1] See pp. 503–508.—ED.

REPORT OF COMMITTEE B-2

ON

NON-FERROUS METALS AND ALLOYS.

Committee B-2 begs to submit the following report of its work during the past year, comprising reports from the various sub-committees which were accepted at the last meeting of the committee on April 25, 1919:

Sub-Committee I on Pure Metals in Ingot Form.—Mr. W. H. Bassett, chairman, has reported that the work of this sub-committee on Tentative Specifications for Lead was practically complete.

The sub-committee believes that specifications for tin and antimony cannot be taken up at the present time for commercial reasons.

The question of Specifications for Casting Copper is being considered, as well as a specification covering Nickel.

Sub-Committee II on Wrought Metals.—Mr. W. R. Webster, chairman, reported that the sub-committee had no new specifications to present this year.

In pursuance of the recommendation of the sub-committee, Committee B-2 recommends that the Tentative Specifications for Cartridge Brass (B 19–18 T), Cartridge Brass Disks (B 20–18 T) and Naval Brass Rods for Structural Purposes (B 21–18 T)[1] be referred to letter ballot of the Society for adoption as standard.

Sub-Committee III on Sand-Cast Alloys.—This sub-committee, Mr. W. M. Corse, chairman, has presented two new Tentative Specifications, appended to this report.[2] The first covers Brass Ingot Metal for Sand Castings and the second covers Bronze Bearing Metal in Ingot Form. Committee B-2 recommends that these two specifications be accepted for publication as tentative.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol XVIII, Part I, p. 472 ff. (1918).

[2] See pp. 490–497.—Ed.

The committee further recommends that the present Tentative Specifications for Bronze Bearing Metals for Turntables and Movable Railroad Bridges (B 22–18 T)[1] be continued as tentative.

Sub-Committee IV on White Metals.—This sub-committee, Mr. G. H. Clamer, chairman, has prepared Tentative Specifications for Solder Metal, appended hereto,[2] which Committee B-2 recommends be accepted for publication as tentative.

The committee further recommends that the present Tentative Specifications for White Metal Bearing Alloys (B 23–18 T)[3] be continued as tentative.

Sub-Committee V on Plates, Tubes and Staybolts for Locomotives.—There is no report to present on behalf of this subcommittee.

Sub-Committee VI on Non-Ferrous Alloys for Railway Equipment.—The question of revision of the Tentative Specifications for Non-Ferrous Alloys for Railway Equipment (B 17–18 T)[4] has been considered, and it has been decided that since this question is at present being taken up by the Government it is unwise to attempt any changes at present. The committee therefore recommends that these specifications be continued as tentative.

Sub-Committee VII on Methods of Analysis.—Mr. W. A. Cowan, chairman, reported that the members of the subcommittee, in cooperation with other chemists, have been working on the standard samples of lead-base and tin-base bearing metals for the comparison of methods for analysis of alloys of lead, tin, antimony and copper. Tentative methods for the analysis of this class of alloys were published in 1917 (B 18–17 T),[5] and the work now being done is for the purpose of deciding whether these shall be adopted as standard or other methods substituted. The latter was suggested by Dr. W. F. Hillebrand, of the Bureau of Standards, and it is following this suggestion that the present work is being done. On this account it seems best not to come to a decision, or make final report until the results of the analyses of the standard samples by the proposed methods have been received from Dr. W. F. Hillebrand, who has advised that their work will not be completed until May 1 or after. The committee therefore recommends that these methods be continued as tentative.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part I, p. 482 (1918).

[2] See pp. 498–502.—ED.

[3] *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part I, p. 487. (1918).

[4] *Ibid.*, p. 467.

[5] *Ibid.*, p. 502.

The committee recommends that the Tentative Methods for Chemical Analysis of Manganese Bronze (B 27–18 T) and for Chemical Analysis of Gun Metal (B 28–18 T),[1] first published in 1918, be referred to letter ballot of the Society for adoption as standard.

It is recommended that the official Method for Battery Assay of Copper, of the American Chemical Society, be proposed for adoption as an A.S.T.M. standard. This method was originally reported by the Sub-Committee on Methods of Analysis of Non-Ferrous alloys, of the Division of Industrial Chemists and Chemical Engineers of the American Chemical Society, by Mr. Wm. B. Price, Chairman. It was approved by the Supervisory Committee on Standard Methods of Analysis and has been adopted as standard by the American Chemical Society. The method is attached hereto,[2] and it is recommended that, in accordance with the regulations of the Society, it first be published as a tentative method.

Sub-Committee VII has prepared Tentative Methods for Chemical Analysis of Pig Lead, to which reference will be made in the specifications for pig lead which are being prepared by Sub-Committee I. Committee B-2 accordingly recommends that these methods be accepted for publication as tentative.

Sub-Committee VIII on Aluminum and Aluminum Alloys.—In pursuance of the report of this sub-committee, Committee B-2 recommends the following modifications in certain Tentative Specifications for Aluminum, which it further recommends be continued as tentative:

Tentative Specifications for Aluminum Ingots (B 24–18 T).[3]—In Sections 4 and 5, change the word "refiner" to "vendor."

Tentative Specifications for Aluminum Sheet (B 25–18 T).[4]—In the table in Section 4, change the headings "Tensile Strength" and "Elongation" to "Minimum Tensile Strength" and "Minimum Elongation," respectively.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part I, pp. 510 ff. (1918).

[2] See pp. 517–522.—ED.

[3] *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part I, p. 492 (1918).

[4] *Ibid.*, p. 494.

Tentative Specifications for Light Aluminum Casting Alloys (B 26-18 T).[1]—In the table of Section 3, change the heading "Total Impurities" to read "Maximum Total Impurities."

In the table in Section 5, change the headings "Tensile Strength" and "Elongation" to "Minimum Tensile Strength" and "Minimum Elongation," respectively.

Also, change the minimum tensile strength for alloy D from 22,000 to 25,000 lb. per sq. in., and insert the value "1 per cent" for the minimum elongation in 2 in.

The sub-committee is still at work on the different grades of aluminum and also on specifications for other alloys than those already covered. On account of the work entailed it has been found impossible to get these changes and additions in proper form to present to the Society this year.

Sub-Committee IX on Nomenclature.—A sub-committee has been formed to take up this question. The membership is as follows:

G. K. Burgess (*Chairman*)
W. H. Bassett,
Wm. Campbell,
J. A. Capp,
G. H. Clamer,
W. M. Corse,
W. A. Cowan,
P. D. Merica,
W. B. Price.

Sub-Committee X on Inspection, Rejection and Claims.—A sub-committee has been formed consisting of the chairmen of the various sub-committees to deal with this question. Some of the specifications of Committee B-2 contain clauses in regard to claims and some do not. It was felt that the matter ought to be standardized and that this could best be done by means of a sub-committee.

In conclusion the committee again requests any suggestions, criticisms or information from members of the Society at large that will in any way help them in their work.

The analysis of the letter ballot vote of the committee is as follows:

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part I, p. 497 (1918).

Items.	Affirmative.	Negative.	Not Voting.
TENTATIVE STANDARDS TO BE ADOPTED AS STANDARD.			
1. For Cartridge Brass (B 19–18 T)	15	1	13
2. For Cartridge Brass Disks (B 20–18 T)	15	1	13
3. For Naval Brass Rods for Structural Purposes (B 21–18 T)	17	0	12
4. Methods for Chemical Analysis of Manganese Bronze (B 27–18 T)	22	1	6
5. Methods for Chemical Analysis of Gun Metal (B 28–18 T)	22	1	6
PROPOSED REVISIONS IN TENTATIVE STANDARDS.			
6. For Aluminum Ingots (B 24–18 T)	19	0	10
7. For Aluminum Sheet (B 25–18 T)	19	0	10
8. For Light Aluminum Casting Alloys (B 26–18 T)	19	0	10
PROPOSED NEW TENTATIVE STANDARDS.			
9. For Brass Ingot Metal for Sand Castings	21	0	8
10. For Bronze Bearing Metal in Ingot Form	21	1	7
11. For Solder Metal	23	0	6
12. Methods for Battery Assay of Copper	23	0	6
13. Methods for Chemical Analysis of Pig Lead	23	0	6

This report has been submitted to letter ballot of the committee, which consists of 64 members, of whom 29 have voted affirmatively, none negatively, and 35 have refrained from voting.

Respectfully submitted on behalf of the committee,

WM. CAMPBELL,
Chairman.

EDITORIAL NOTE.

The Tentative Specifications for Cartridge Brass, the Tentative Specifications for Cartridge Brass Disks, the Tentative Specifications for Naval Brass Rods for Structural Purposes, the Tentative Methods for Chemical Analysis of Manganese Bronze, and the Tentative Methods for Chemical Analysis of Gun Metal referred to in this report were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1919, and appear in the Supplementary Pamphlet of A.S.T.M. Standards Adopted in 1919.

The proposed Tentative Specifications for Brass Ingot Metal for Sand Castings, with amendments as indicated in the Summary of the Proceedings, pages 25–26; the proposed Tentative Specifications for Bronze Bearing Metal in Ingot Form, with amendments as indicated in the Summary of the Proceedings, page 26; the proposed Tentative Specifications for Solder Metal, the proposed Tentative Methods for Battery Assay of Copper, and the proposed Tentative Methods for Chemical Analysis of Pig Lead were accepted for publication as tentative and appear on pages 490–502 and 517–532.

The proposed Tentative Specifications for Lead presented as an addendum to the report of the committee (see Summary of the Proceedings, page 25) were subsequently approved by letter ballot of the committee, and the specifications therefore appear among the tentative standards of the Society on pages 483–489.

The revisions recommended in the Tentative Specifications for Aluminum Ingots for Remelting and for Rolling, in the Tentative Specifications for Aluminum Sheet and in the Tentative Specifications for Light Aluminum Casting Alloys were approved and the specifications appear in their revised form on pages 473–482.

DISCUSSION.

Mr. Woodward.

MR. R. W. WOODWARD (*by letter*).—There have been several instances of late in which specifications for alloys as drawn up by committees contain provisions for test specimens which do not conform to those recommended in the Standard Methods for Testing (E 1-18) of the Society.

Such a case exists in the proposed Tentative Specifications for Bronze Bearing Metal in Ingot Form.[1] The table showing physical properties of the various bronze bearing metals, while not actually a part of the specifications, is vitally concerned with it and should conform to the standards of the Society.

In this table the compression tests were made on test specimens "of 1 sq. in. sectional area, 1 in. high." Presumably this was a cylindrical specimen, although it is not so stated.

In the Standard Methods for Testing it is stated that "the length of the specimen should be between 2.5 and 4 diameters. It is believed that a length of less than 2.5 diameters is not sufficient for the internal shear to be properly developed, and that such short lengths give a fictitious strength owing to the friction of the bearing plates of the machine, which causes the specimen to assume a barrel-like form."

The proposed specifications also define the elastic limit "as the load producing a compression in the specimen of 0.001 in.," which again does not correspond to elastic limit as defined in the Standard Methods.

In view of the above the value of that column of the table giving "Compression, Elastic Limit" is much in doubt and it is recommended that the last column of the table be revised to give "Compression, Yield Point," such determinations to be made on cylindrical specimens of 1 sq. in. sectional area and 3 in. high and the yield point to be determined as defined in the Standard Methods for Testing.

Again, in the Tentative Specifications for Babbitt Metal (B 23–18 T),[2] which the committee recommends be continued

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[1] See pp. 494–497.—ED.

[2] See pp. 468–472.—ED.

Mr. Woodward. as tentative, there is a similar occurrence. In the table of Physical Properties of White Metal Bearing Alloys accompanying the above specifications, the specimen for determining deformation under compression is $1\frac{1}{4}$ in. in diameter by $2\frac{1}{2}$ in. high, both of which dimensions disagree with those recommended in the Standard Methods for Testing.

Also, rather than to give the actual deformations which take place under definite loads, it would be preferable to give the yield point, ultimate compressive strength, modulus of elasticity and possibly proportional limit in compression. The data given, namely, deformation at 1000, 5000, and 10,000 lb. total load, make it difficult if not impossible to determine these constants for the various alloys, since for some of the alloys loads of both 5000 and 10,000 lb. per sq. in. are beyond the yield point. The data as now given are of little use in the design of bearings or for comparison of various babbitt metals and it is recommended that the table be revised as suggested before submitting to the Society for adoption as standard.

Mr. Deacon. MR. R. W. DEACON (*by letter*).—In reference to the report of Committee B-2 there are one or two suggestions which I should like to make for the consideration of the committee.

In the proposed Tentative Methods for Battery Assay of Copper,[1] the paragraph on "Electrodes" contains the following statement: "This sheet is formed into a cylinder of the open type, and the stem is riveted and soldered with gold to the middle of the sheet." We have discarded entirely this type of electrode and substituted one in which the stem is electrically welded to the cylinder; no rivets or solder are used. We find that this is much more reliable and durable, and in specifying a standard it would seem wise to call for the type which has been found to be most satisfactory.

In the first paragraph under the heading "Method" the last sentence reads: "Wash the cover and the sides of the beaker and dilute the solution to 150 cc. and electrolyze." I would suggest that it would be well to add to this sentence, "keeping the top of the cathode $\frac{1}{4}$ in. below the surface of the solution."

With respect to the Tentative Methods for Chemical Analysis of Manganese Bronze (B 27–18 T), which the com-

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[1] See pp. 517–522.—ED.

Mr. Deacon.

mittee is recommending for adoption as standard, I should like to call attention to the direction under "Determination of Lead as Sulfate" for preparing dilute alcohol for washing, namely: "Mix equal parts of denatured alcohol and distilled water." All denatured alcohol is not satisfactory and one should be used which will leave no deposit on the cylinders. Alcohol denatured with methyl alcohol would be satisfactory, but if denatured with carbolic acid it may give trouble. Might it not be wise to have a note added with reference to the kind of denatured alcohol to be used?

Again, in the Tentative Methods for Chemical Analysis of Gun Metal (B 28–18 T), which the committee is also recommending for adoption as standard, I should like to call attention to the following sentence under the title "Method" relating to "Determination of Copper by the Electrolytic Method": "When the action has ceased, boil until the oxides of nitrogen are expelled, add 50 cc. of hot distilled water, etc." In the notes at the end of this method reference is made to the initial removal of the tin. In order that the chemist might not be led astray, I would suggest that the above sentence be changed to read as follows: "When the action has ceased, boil until the oxides of nitrogen are expelled, evaporate the solution to dryness and bake on the edge of a hot plate to allow all the metastannic acid to separate out. Then take up with 50 cc. of hot distilled water, etc." This will eliminate any trouble from tin at this point in the determination of copper.

REPORT OF COMMITTEE C-1

ON

CEMENT.

Committee C-1 on Cement must this year duplicate to an extent the report made to the Society at the last annual meeting, for this generally active committee has not yet "caught its stride" since its work was interrupted by pressure of war activities. The committee has had one interim meeting which was held Tuesday, January 14, 1919, in the Engineering Societies Building in New York City.

Some of the sub-committees have, during the past few months, again taken up their work, and others are planning to do so soon. The questions of Fineness, Time of Setting, and Strength are still live subjects, and on the study of these, some important work is yet to be done. It is probable that within the year a final sub-committee report will be made on at least one of these subjects. The question of relative value of the tensile and compressive strength tests should also have been studied extensively enough by then so that a positive recommendation can be made on the present Tentative Specifications and Tests for Compressive Strength of Portland Cement Mortars (C 9–16 T).[1]

Recently the secretary of this committee has edited and placed in the hands of a printer the copy of the data secured by Committee C-1 in its extensive research and studies on the subjects of Uniform Methods of Tests and Standard Specifications for Cement. This committee has felt that these data, together with the Report of the Joint Conference Committee on the same subjects, should be preserved and therefore directed their publication. The printed volume should be ready for distribution before long.

In conclusion, Committee C-1 recommends solely at this time that the Tentative Specifications and Tests for Compressive Strength of Portland Cement Mortars be continued as tentative.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part I, p. 538 (1918).

This report has been submitted to letter ballot of the committee, which consists of 56 members, of whom 49 have voted affirmatively, none negatively, and 7 have refrained from voting.

Respectfully submitted on behalf of the committee,

RUSSELL S. GREENMAN,
Chairman.

P. H. BATES,
Secretary.

REPORT OF COMMITTEE C-2
ON
REINFORCED CONCRETE.

Committee C-2 on Reinforced Concrete begs to report that on August 16, 1917, a communication was addressed to the Acting Secretary in which he was requested to extend on behalf of the Society to the American Society of Civil Engineers, the American Railway Engineering Association, the American Concrete Institute, and the Portland Cement Association, an invitation to cooperate with Committee C-2 in the preparation of specifications for reinforced concrete. On October 13, 1917, the committee was advised by the Secretary of the Society that this request had been "laid on the table, without prejudice, pending action on the report of a committee which the President has been authorized to appoint, with instructions to report its recommendations to the Executive Committee, on a definite line of policy on the general subject of the resolution introduced at the last annual meeting concerning 'the formation and methods of procedure to be followed by joint committees and the publication of joint reports,' etc." On February 4, 1918, the Secretary advised the committee that its request had been "again laid on the table pending a report from Committee E-5 on certain proposed amendments to the Regulations Governing Standing Committees, etc."

On April 25, 1919, the Assistant Secretary of the Society advised that the request of the committee had been favorably acted upon by the Executive Committee and that within the next few days invitations would be extended to the societies named in the committee's communications, inviting them to appoint committees to cooperate with Committee C-2 in the preparation of specifications for reinforced concrete. An acceptance has already been received from one of the societies and it is expected that the matter will be acted upon by the others prior to July 1.

The committee at its meeting on June 3, after careful consideration, decided that it would take no definite action in the preparation of specifications for reinforced concrete until all the committees appointed by the several societies invited could meet in a joint session.

In view of the work before the committee it was deemed desirable to increase its membership, so that there would be an adequate representation from the membership of the Society of those interested in this subject. The committee, with the approval of the Executive Committee of the Society, has added the following new members:

D. A. Abrams
R. W. Boyd
A. B. Cohen
S. E. Hollister
L. J. Johnson
A. B. MacMillan
W. A. Slater
C. A. P. Turner
H. C. Turner

The committee discussed its future work in a preliminary way, and tentatively agreed upon the following sub-committees with chairmen as indicated:

SUBJECT.	CHAIRMAN.
Aggregates	S. E. Thompson
Metal Reinforcement	H. H. Quimby
Mixing and Placing	D. A. Abrams
Proportioning	W. A. Slater
Forms	A. B. MacMillan
Inspection and Supervision, Including Work in Freezing Weather	H. C. Turner
Depositing and Curing	R. W. Boyd
Details of Construction	L. S. Moisseiff
Waterproofing	G. S. Webster
Fireproofing	R. W. Lesley
Arrangement and General Clauses	S. T. Wagner

This report has been submitted to letter ballot of the committee, which consists of 11 members, 9 of whom have voted affirmatively, none negatively, and 2 have refrained from voting.

Respectfully submitted on behalf of the committee,

RICHARD L. HUMPHREY,
Chairman.

SAMUEL T. WAGNER,
Secretary.

REPORT OF COMMITTEE C-3

ON

BRICK.

Committee C-3 has held two meetings during the year and submits a report consisting of two parts:

First, a recommendation to the Society for the adoption of Tentative Specifications for Building Brick, unanimously approved at the meeting held in Pittsburgh, Pa., March 7, 1919, and submitted to a vote by letter ballot, with the following results: affirmative, 11; negative, none; not voting, 3; total, 14.

Second, a report by Col. Edward Orton, Jr., entitled, "A Study of the Proposed A.S.T.M. Tentative Specifications for Building Brick and a Correlation of Their Requirements with Sodium-Sulfate Treatment and Actual Freezing." This contribution was accepted as constituting part of the committee report, at a meeting held June 26, 1918, at Atlantic City, when it was voted also to submit it for publication by the Society. Owing to the voluminous character of the paper it appears in separate form as an Appendix to the report.

The proposed Tentative Specifications for Building Brick are the result of work which has extended over a number of years. In 1913 it was decided to collect data on the mechanical strength of building brick for the purpose of arriving at a reasonable and fair classification. The results of many tests were correlated but the need for additional information became apparent. Arrangements were completed in 1914 for cooperation with a number of University engineering laboratories and bricks from many states were tested, employing uniform methods of procedure. These results were published in the 1915 report of the committee.[1] At a meeting held June 24, 1915, the tentative classification substantially as given in the present report was approved after careful consideration of the data. The ruling covering the standing of a set of bricks with reference to the requirement in which it is lowest was adopted on June

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XV, Part I, p. 150 (1915).

28, 1916. At this time the sodium-sulfate test was proposed as a criterion of the durability and weather resistance of building bricks. Owing to the favorable evidence advanced Col. Edward Orton offered to conduct an extensive investigation correlating the mechanical properties of typical building brick from various parts of the country with their resistance to ice and sodium-sulfate freezing. This elaborate study was undertaken by Colonel Orton, largely financed by himself, and the results are embodied in the report of the committee for this year. The usefulness of the sodium-sulfate tests for differentiating clay bricks as to their probable resistance to weathering agencies has been shown, but owing to the vigorous action of the salt upon bricks made from other materials, due perhaps to chemical reaction, the test has not yet been included in the proposed tentative specifications.

This report has been submitted to the letter ballot of the committee, which consists of 14 members, of whom 11 have voted affirmatively, none negatively, and 3 have refrained from voting.

Respectfully submitted on behalf of the committee,

A. V. BLEININGER,
Acting Chairman.

EDITORIAL NOTE.

The proposed Tentative Specifications for Building Brick referred to in this report were accepted for publication as tentative and appear on pages 537–542.

APPENDIX.

A STUDY OF THE PROPOSED A.S.T.M. TENTATIVE SPECIFICATIONS FOR BUILDING BRICK AND A CORRELATION OF THEIR REQUIREMENTS WITH SODIUM-SULFATE TREATMENT AND ACTUAL FREEZING.

By Edward Orton, Jr.

During 1913–1914 Committee C-3 on Building Brick solicited the cooperation of several of the state universities in making a series of tests on building brick. At that time the committee sent out data sheets containing complete directions for the tests and setting forth as a basis for classification the tentative standards given in Table I.

It is recognized that the tests specified by the tentative method are all more or less indirect, in that they do not completely assure us of the ability or failure of a brick to resist actual freezing when thoroughly wet. The effect of freezing is in most cases what we really wish to know. Inasmuch as a thorough laboratory freezing test requires expensive equipment such as is not generally found in our testing departments, and consumes considerable time, this test obviously cannot come into general use.

The simplicity of the sodium-sulfate test, however, and the comparatively short time required for getting results, makes it a test that can be readily applied almost anywhere at any time. W. L. Howat, of the Bureau of Standards, has published a valuable paper[1] on the use of sodium-sulfate solution as a mode of producing, artificially, and at convenient temperatures, the disruptive effect of freezing of water in the pore spaces of brick. Mr. Howat showed that the test is sharp and decisive in breaking down the structure of clays which have not yet reached their full strength, but concluded that it was too severe to be adopted without modification. His work, however, was conducted upon laboratory-made briquettes and upon relatively few specimens. In this work a concentrated solution at approximately 33° C. was used, which would contain approximately 33 grams of anhydrous salt per 100 grams of solution.

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[1] *Transactions*, Am. Ceramic Soc., Vol. 17.

This work formed the basis for a series of similar tests conducted by the writer[1] on building brick from fourteen different plants in Ohio. Saturated sodium-sulfate solution at approximately 21° C. was used. Such a solution would contain approximately 17 grams of anhydrous salt per 100 grams of solution.

TABLE I.—BASIS OF CLASSIFICATION.

Name of Grade.	Absorption Limits, per cent.		Compressive Strength (on edge), lb. per sq. in.		Modulus of Rupture, lb. per sq. in.	
	Mean of 5 Tests.	Individual Maximum.	Mean of 5 Tests.	Individual Minimum.	Mean of 5 Tests.	Individual Minimum.
Vitrified Brick.	5 or less	6.0	5000 or over	4000	1200 or over	800
Hard Brick....	5 to 12	15.0	3500 or over	2500	600 or over	400
Medium Brick.	12 to 20	24.0	2000 or over	1500	450 or over	300
Soft Brick.....	20 or over	No limit	1000 or over	800	300 or over	200

This work gave still further evidence of the value of this test and suggested the desirability of extending the tests to brick from representative districts throughout the United States. But it was recognized that in order to get the most value from the work, concurrent tests by actual freezing should be made.

Accordingly the following work was undertaken: Samples of building brick containing 30 hard-burned, 30 medium-burned and 30 soft-burned bricks were solicited from various parts of the country. Fourteen such lots were collected.

Absorption tests were made on all the bricks by weighing the brick, previously dried at 110° C. for 48 hours, and again after boiling for five hours in water and allowing to cool down in the water. The absorption was calculated in per cent of the dry weight by the usual formula:

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[1] *Transaction*, Am. Ceramic Soc., Vol. 18.

$$\text{Per cent absorption} = \frac{100 \text{ x (wet weight—dry weight)}}{\text{dry weight}}.$$

The bricks representing each degree of hardness were then graded by absorption into four groups of five each, making the individual and average absorption of each of the four groups as nearly as possible like the others. The groups were intended for the following tests: (1) compression, (2) transverse, (3) sodium-sulfate freezing, (4) actual ice freezing. The bricks not needed were discarded. In most cases it was possible to select four groups with an average absorption varying less than 0.5 per cent. The total number of different bricks used in these absorption tests was approximately 1200.

The compression tests were conducted on half bricks on edge. The specimens were prepared by sawing the whole brick around with a thin corundum wheel to a depth of $\frac{1}{4}$ in. and then breaking along this line with a broad chisel. The top and bottom surfaces of the specimens were then shellaced and trued up with plaster between parallel pieces of plate glass. A spherical bearing block was used between the plates of the testing machine, and the tests were made on a 200,000-lb. Olsen machine.

The transverse tests were conducted in the manner prescribed by the A. S. T. M. tentative methods, and the bricks were broken on supports 7 in. apart with load applied at mid-span. The modulus of rupture, or tensile strength of brick as calculated from the transverse test, was computed from the formula

$$R = \frac{3\,W\,l}{2\,b\,d^2}$$

where W = load applied, l = distance between supports in inches, b = width of brick at central portion in inches, and d = depth of brick in inches at central portion. This work was done on a 100,000-lb. Olsen machine using a 50,000 beam weight so as to give a comparative large travel of weight for a small increment in pressure.

SODIUM-SULFATE TESTS.

Considerable comment has been made upon the possibility of wide variation in the concentration of sodium-sulfate solution obtainable due to its different degrees of solubility at different temperatures. At 15° C. a saturated solution of sodium-sulfate contains 11.8 grams of anhydrous sodium sulfate per 100 grams of solution, while at 32.75° C. it contains 33.6 per cent of anhydrous salt and at 21° C. (70° F.) approximately 17 per cent of the anhydrous salt. Thus it will be seen that the solubility increases rapidly with an increase in temperature, and conversely, that a saturated solution at any given temperature becomes supersaturated with a slight decrease in temperature.

In the light of these facts, it was decided to use a 14-per-cent solution at a temperature approximating 21° C. (70° F.). This solution can be cooled to 18° C. before crystallization begins, and it can be raised to say 30° C. without materially affecting the concentration.

In practice, the method employed to keep the solution at nearly constant saturation was as follows: Care was taken to have it always at a temperature at or above 21° C., and at the same time to keep the specific gravity as indicated by a hydrometer between 1.13 and 1.14. This was found to be a very quick and easy method of keeping the solutions standard; for, if we start with a solution of sodium sulfate containing 14 grams of anhydrous salt per 100 grams of solution and keep that solution within the limits of 18° C. and 30° C., maintaining the specific gravity constant at 1.13, the percentage composition can be affected only by the change in volume of the liquid within that temperature range. This change in volume is almost negligible.

Part of these experiments were carried on during cold weather when the room temperature during the night would fall as low as 10° C., attended by the formation of large crystals of sodium sulfate in the bottom of the tank and on the surfaces of the bricks being treated. Inasmuch as this cooling always happened several hours after the bricks had become thoroughly saturated with the brime at normal temperatures, it is not believed to have had any material effect on the test. A solution showing such crystal separation was readily brought back to standard condition by taking out a portion of the liquor, heating it, and returning it to the tank, thus increasing the temperature of the whole with the attendant re-dissolving of the crystals.

Details of the Test.—The previously dried bricks were placed on edge in an iron rack holding 30 bricks. This rack was lowered into a rectangular tank containing about 35 gallons of the solution. The bricks were allowed to remain in the solution for 22 hours. The rack was then removed and placed in a similar tank containing only a few inches of water. The rack was supported within this tank so that the bottom bricks did not touch the water. The tank was covered and the bricks were steamed for one hour. They were then placed in an oven previously heated to 110° C., and kept at this temperature for 22 hours. The purpose of the steaming was to raise the temperature of the bricks without allowing evaporation to take place, so that when placed in the oven the crystallization of the salt in the pores of the brick would be rapid and complete. This heat treatment was kept uniform with the intent to produce crystallization of the anhydrous salt, Na_2SO_4. It should be stated in passing that the anhydrous salt occupies a much smaller volume than the $Na_2SO_4 \cdot 10\ H_2O$ crystal, this being evidenced by the difference in specific gravity. The latter salt has a specific gravity of 1.49 while this value for the anhydrous salt is 2.67. This explains why it is important that the oven treatment be quickly and carefully applied after taking the bricks from the solution, as the object is to produce the smaller crystals of the anhydrous salt and thus reduce the severity of any one treatment. The bricks were then removed from the oven and "thawed" for 30 minutes in the standard salt solution. This cycle constituted one sodium-sulfate treatment. The condition of the bricks was then noted, and they were photographed. All samples were given five successive treatments, each complete treatment requiring 48 hours.

FREEZING TREATMENT.

For the freezing treatment the refrigeration plant of the Mechanical Engineering Department of The Ohio State University was used. The equipment consists of a 10-ton Triumph ice machine and two refrigeration rooms. The larger or chill room is 9 by 16 ft., while the smaller or cold room is 6 by 16 ft. The bricks were placed on flat, 1 in. apart, in shallow galvanized iron pans holding five bricks each. The pans were partly filled with water so as to bring the water up half way on the edge faces of the brick. These pans were placed in a rack-truck that would hold twenty or more pans. Two such trucks were used. The loaded trucks were placed in the chill room for 6 hours, then transferred to the cold room for 16 hours. The temperature of the chill room was kept at 16 to 20° F. and the bricks were always frozen when transferred to the cold room. The temperature of the latter room ranged from 15° above to 10° below 0°F. The pans were then placed in water at about 200° F. and allowed to remain for one hour, or until the bricks were thoroughly thawed and warmed through. After each five freezings the samples were photographed. Twenty-five successive freezings were made.

TABLE II.—DISINTEGRATION RATINGS.

Symbol.	Interpretation.	Number of Sample Illustrating This Type.
A.	No apparent effect.	Sample E. Groups 1 and 2. Fig. 1.
B.	Very slight superficial disintegration without cracking. No apparent loss of strength.	Sample D. Groups 1 and 2. Fig. 2.
C.	Considerable superficial disintegration, loss of some corners or edges probable or development of small cracks without disintegration. No evidence of marked internal weakening.	Sample I. Group 2. Fig. 3.
D.	Severe superficial disintegration with loss of corners and edges or development of serious structural cracks. Internal weakening evident.	Sample L. Group 1. Fig. 4.
E.	Mutilation by splitting off of large pieces, or breaking into bats. Structure shaky and strength practically gone.	Sample K. Group 3. Fig. 5.
F.	Complete failure.	Sample I. Group 2. Fig. 6.

In order to condense the data the disintegration ratings given in Table II, used in the former work on Ohio brick by the writer, have been used here again to express the various stages of destruction which the different samples exhibited.

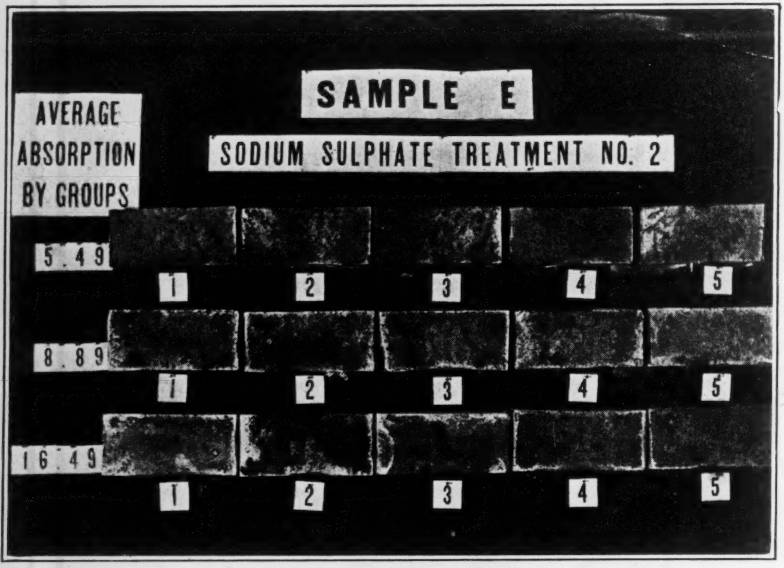
SAMPLE E
AVERAGE ABSORPTION BY GROUPS
SODIUM SULPHATE TREATMENT NO. 2
5.49
1
2
3
4
5
8.89
1
2
3
4
5
16.49
1
2
3
4
5

FIG. 1.—Bricks Showing no Apparent Effect of Sodium-Sulfate Treatment; Graded as A.

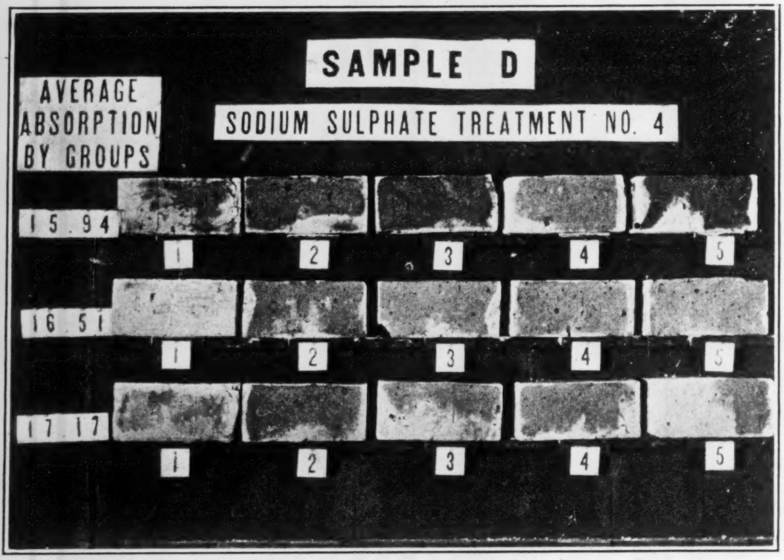
SAMPLE D
AVERAGE ABSORPTION BY GROUPS
SODIUM SULPHATE TREATMENT NO. 4
15.94
1
2
3
4
5
16.51
1
2
3
4
5
17.17
1
2
3
4
5

FIG. 2.—Bricks Showing Slight Superficial Disintegration; Graded as B.

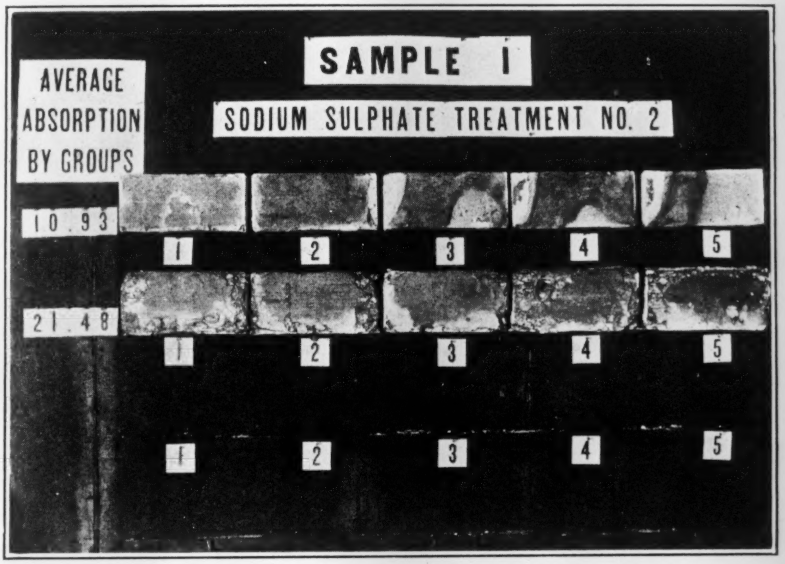
SAMPLE I
SODIUM SULPHATE TREATMENT NO. 2
AVERAGE ABSORPTION BY GROUPS
10.93
21.48
1
2
3
4
5
1
2
3
4
5
1
2
3
4
5

FIG. 3.—Bricks of Lower Row Showing Considerable Superficial Disintegration and Loss of Corners and Edges; Graded as E.

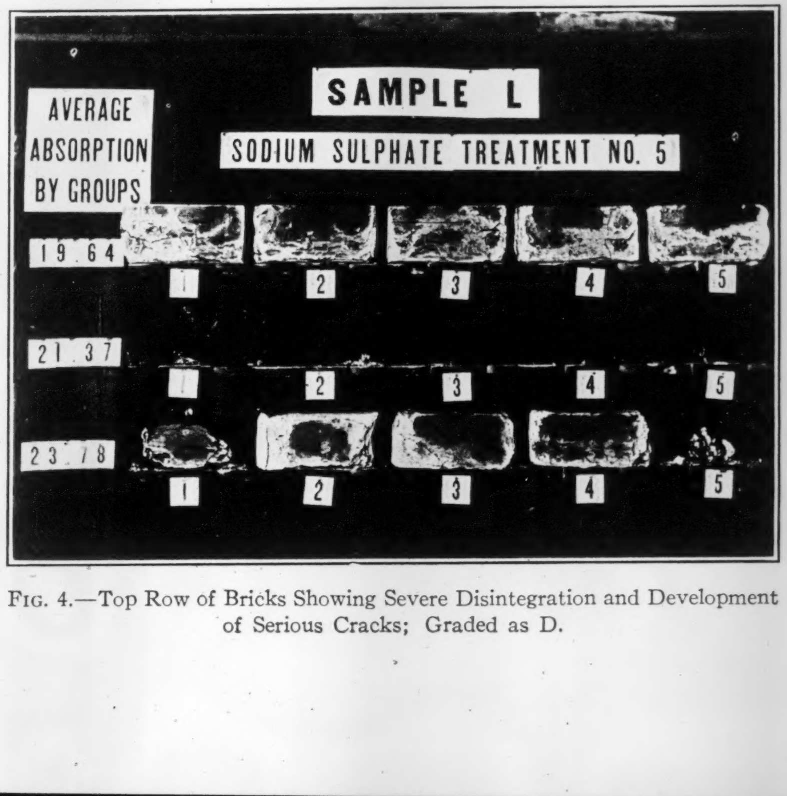
SAMPLE L
SODIUM SULPHATE TREATMENT NO. 5
AVERAGE ABSORPTION BY GROUPS
19.64
21.37
23.78
1
2
3
4
5
1
2
3
4
5
1
2
3
4
5

FIG. 4.—Top Row of Bricks Showing Severe Disintegration and Development of Serious Cracks; Graded as D.

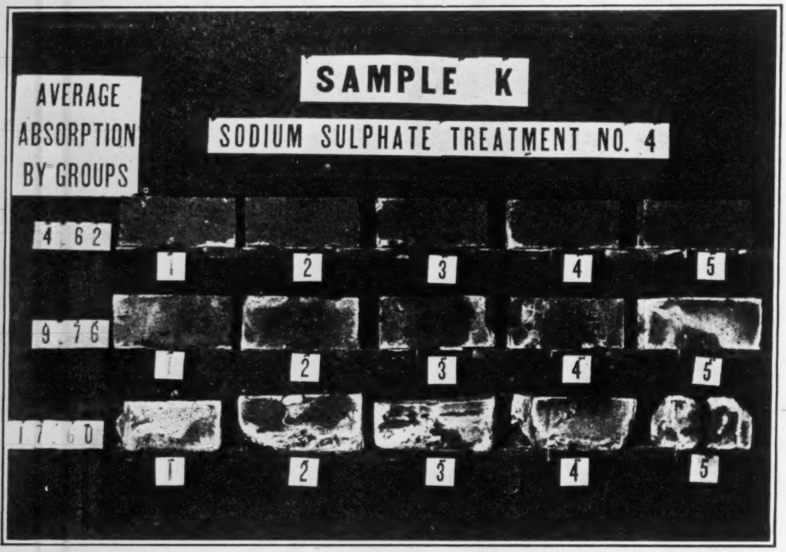
SAMPLE K
SODIUM SULPHATE TREATMENT NO. 4
AVERAGE ABSORPTION BY GROUPS
4.62
9.76
17.60
1
2
3
4
5

FIG. 5.—Bottom Row of Bricks Seriously Damaged by Splitting off of Large Pieces, Strength Practically Destroyed; Graded as E.

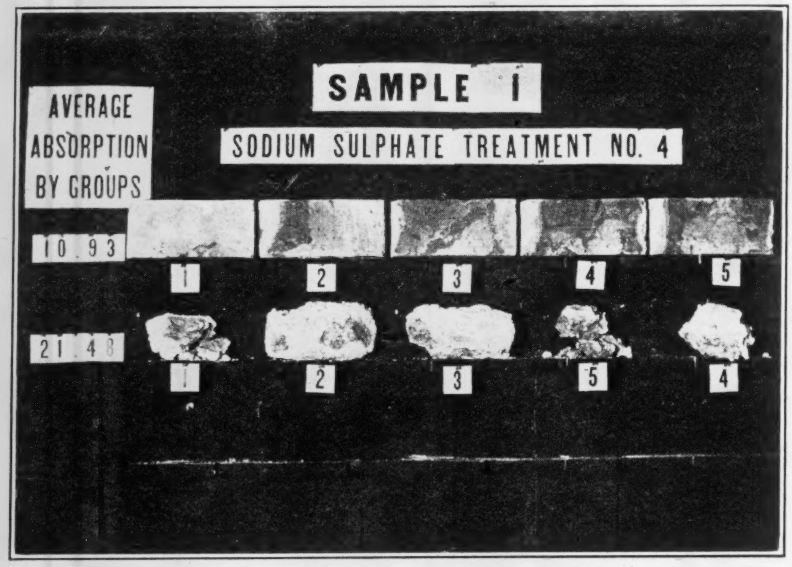
SAMPLE I
SODIUM SULPHATE TREATMENT NO. 4
AVERAGE ABSORPTION BY GROUPS
10.93
21.48
1
2
3
4
5

FIG. 6.—Lower Row of Bricks Showing Complete Failure; Graded as F.

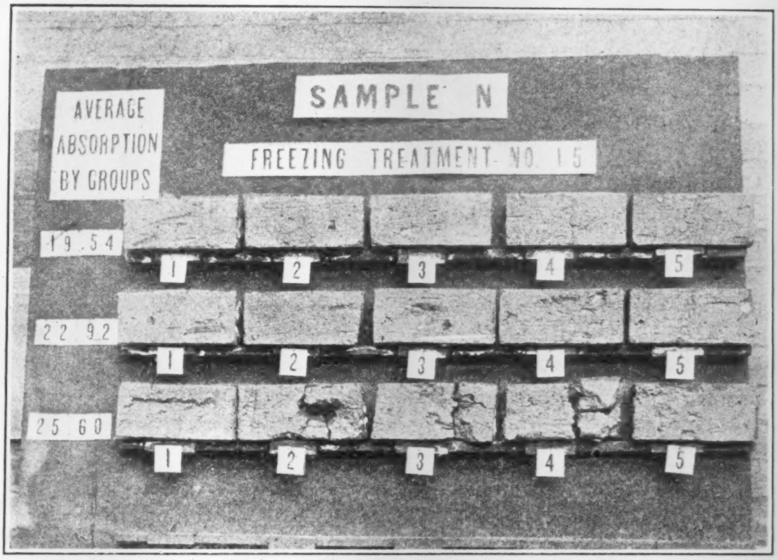
AVERAGE ABSORPTION BY GROUPS
SAMPLE N
FREEZING TREATMENT NO. 15
19.54
1 2 3 4 5
22.92
1 2 3 4 5
25.60
1 2 3 4 5

FIG. 7.—Bottom Row of Bricks Seriously Damaged by Ice Freezing; Graded as E.

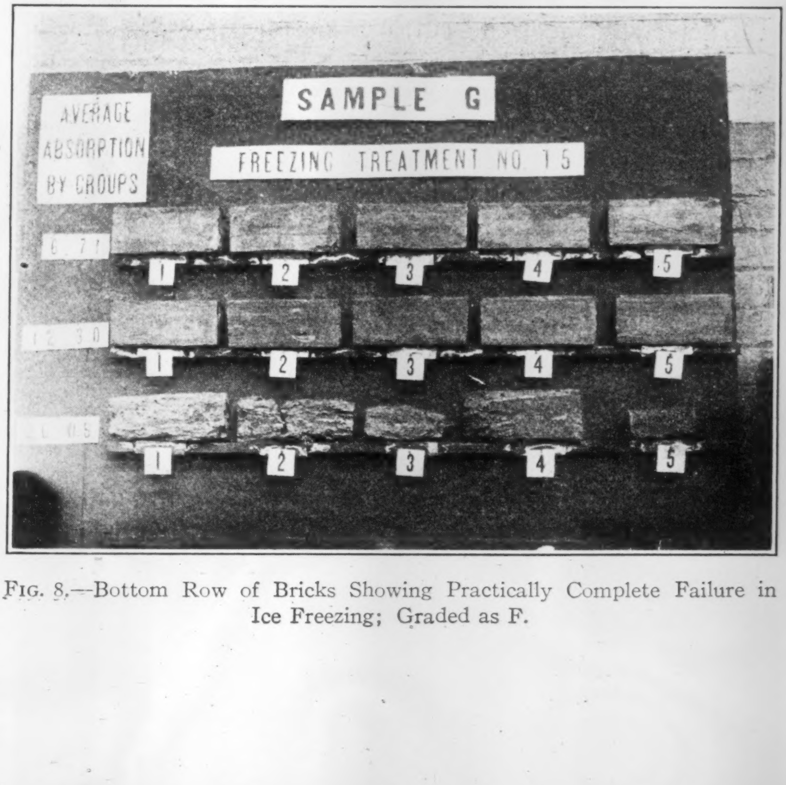
AVERAGE ABSORPTION BY GROUPS
SAMPLE G
FREEZING TREATMENT NO 15
6.71
1 2 3 4 5
12.30
1 2 3 4 5
1 2 3 4 5

FIG. 8.—Bottom Row of Bricks Showing Practically Complete Failure in Ice Freezing; Graded as F.

THE SAMPLES.

Fourteen lots of brick were obtained. Their geographical sources were as follows: New Hampshire, 1; Massachusetts, 1; New York, 2; New Jersey, 1; Maryland, 2; Michigan, 1; Ohio, 1; Kentucky, 1; Illinois, 1; Missouri, 1; Louisiana, 1; Colorado, 1.

An accurate classification of the kinds of clays represented cannot be given, but in general it may be said that all clays were red burning material. There were six or more distinctly surface clays, of which some were glacial in origin and some were of sedimentary character. The Hudson River common brick industry was represented by two lots, and the tough plastic variegated clays of the southern Atlantic seaboard were represented by two samples; the surface clays of the St. Louis district, probably loess material, by two samples; the coal measure shales of the Kentucky field, by one lot; the delta deposits of New Orleans district by one lot; and the volcanic shales of Pueblo, Colo., by one lot. Thus it will be seen that a wide variety of raw materials were represented by the samples. The processes of manufacture were represented as follows: soft mud, seven lots; soft mud, repressed, one lot; stiff mud, side cut, two lots; stiff mud, end cut, one lot; dry pressed, three lots.

STUDY OF THE RESULTS OF THE TESTS.

We shall first compare the results of the sodium-sulfate treatment with those of the actual freezing, and then compare the relative values of these tests and the so-called indirect tests prescribed by the A. S. T. M. tentative standards.

Previous work by Messrs. Howat, Orton and others has demonstrated that five sodium-sulfate treatments are quite sufficient to give a rigorous test that will bring out any weaknesses of structure. The requisite number of actual ice freezings is not so easy to determine, but as the test is so slow and costly a limit must of necessity be set somewhere. It is believed that twenty-five rapid freezings followed by sudden and complete thawing and heating up to temperatures equivalent to summer conditions, must certainly subject the samples to considerably more punishment than the same number of freezings under actual conditions obtaining where the brick are laid in the wall with but one surface exposed, and when complete saturation with water is seldom possible. Furthermore, it has been observed that the process of disintegration due to actual freezing is slow at first, then more rapid, and then slows down again so that toward the end of twenty-five freezings the effect of each successive treatment grows less and less. It is, therefore, assumed that twenty-five freezings carry the process far enough to give a good indication of the resisting qualities of any given product. Such were the considerations that led to the decision to stop with twenty-five actual freezings.

Most of the fourteen lots of samples were furnished in three groups, namely, hard-burned, medium-burned and soft-burned; but of some lots only one or two degrees of hardness were furnished so that the total number of groups tested was thirty-seven.

Figs. 7 and 8 illustrate types of failure in ice freezing corresponding to ratings E and F.

The data for the complete tests on each of the fourteen groups are recorded on Tables III to XVI, inclusive, which are arranged in the order in which the samples were tested, and without regard to the process of manufacture.

A casual examination of the foregoing data seems to indicate that the third sodium-sulfate treatment is the important one in simulating the effect of twenty-five actual freezings. A closer analysis shows that the effect of the third sodium-sulfate treatment was equal to twenty-five freezings in 23 groups; that it was more severe than twenty-five freezings in 8 groups; and that it was less severe than twenty-five freezings in 6 groups. We may say, therefore, that the third sodium-sulfate treatment was equal to or better than twenty-five freezings in 66 per cent of all groups, and that it was less severe in 34 per cent of all groups. A similar analysis carried to the fourth sodium-sulfate treatment shows that it is equal to twenty-five freezings in 19 groups; that it is more severe than twenty-five freezings in 15 group; and that it is less severe than twenty-five freezings in 3 groups. The fourth sodium-sulfate treatment, therefore, is equivalent to or better than twenty-five freezings in 92 per cent of all groups, and is less severe in 8 per cent of all groups. It is a notable fact that two of the three groups constituting the

TABLE III.—SAMPLE "A."

Process of Manufacture: Dry Press.

Kind of Clay: Red Burning Surface Clay.

Group and Makers Grade.	Compressive Strength on Edge, lb. per sq. in. (Mean of 5 Tests).	Modulus of Rupture, lb. per sq. in. (Mean of 5 Tests).	Absorption, per cent.	Condition of Bricks after Freezing Treatments, expressed in Disintegration Ratings. Data shown on 5 Sodium-Sulfate Treatments and 25 Actual Freezings.
Hard (1)	11248	1311	No. 1...11.20 2...11.82 3...11.90 4...12.44 5...12.03 Av..11.88 1...11.93 2...12.41 3...12.05 4...11.56 5...11.39 Av..11.87	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............. A A A A A Actual Freezing Treatments. Number............ 5 10 15 20 25 Rating............. A A A A A
Medium (2)	3588	348	No. 1...18.80 2...18.50 3...17.80 4...18.75 5...18.91 Av..18.55 1...18.72 2...18.85 3...18.31 4...19.05 5...17.83 Av..18.55	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............. A A C C C Actual Freezing Treatments. Number............ 5 10 15 20 25 Rating............. A A A A A
Soft (3)	2062	289	No. 1...20.24 2...20.33 3...19.60 4...21.12 5...20.70 Av..20.40 1...19.75 2...20.15 3...20.43 4...20.15 5...21.60 Av..20.41	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............. A B C C C Actual Freezing Treatments. Number............ 5 10 15 20 25 Rating............. A A A A A

TABLE IV.—SAMPLE "B."

Process of Manufacture: Soft Mud.

Kind of Clay: Alluvial Clay.

Group and Makers Grade.	Compressive Strength on Edge, lb. per sq. in. (Mean of 5 Tests).	Modulus of Rupture, lb. per sq. in. (Mean of 5 Tests).	Absorption, per cent.	Condition of Bricks after Freezing Treatments, expressed in Disintegration Ratings. Data shown on 5 Sodium-Sulfate Treatments and 25 Actual Freezings.
Medium (1)	3610	554	No. 1...19.31 2...18.70 3...18.45 4...18.70 5...19.70 Av..18.97 1...18.75 2...19.75 3...18.55 4...19.10 5...18.65 Av..18.96	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............. A A B D F Actual Freezing Treatments. Number............ 5 10 15 20 25 Rating............. A A A A B

TABLE V.—SAMPLE "C."

Process of Manufacture: Soft Mud.

Kind of Clay: Alluvial Clay.

Group and Makers Grade.	Compressive Strength on Edge, lb. per sq. in. (Mean of 5 Tests).	Modulus of Rupture, lb. per sq. in. (Mean of 5 Tests).	Absorption, per cent.	Condition of Bricks after Freezing Treatments, expressed in Disintegration Ratings. Data shown on 5 Sodium-Sulfate Treatments and 25 Actual Freezings.
Medium (1)	9350	615	No. 1...17.47 2...17.27 3...14.10 4...15.53 5...15.21 Av..15.91 1...15.04 2...15.80 3...13.75 4...17.56 5...16.80 Av..15.79	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............. A A A A A Actual Freezing Treatments. Number............ 5 10 15 20 25 Rating............. A A A A A
Soft (2)	8828	788	No. 1...20.93 2...20.61 3...19.90 4...19.90 5...19.68 Av..20.20 1...20.58 2...19.46 3...20.80 4...19.56 5...20.34 Av..20.15	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............. A C C D E Actual Freezing Treatments. Number............ 5 10 15 20 25 Rating............. A A A A A

TABLE VI.—SAMPLE "D."

Process of Manufacture: Stiff Mud, Side Cut.

Kind of Clay: River Bottom Deposit.

Group and Makers Grade.	Compressive Strength on Edge, lb. per sq. in. (Mean of 5 Tests).	Modulus of Rupture, lb. per sq. in. (Mean of 5 Tests).	Absorption, per cent.	Condition of Bricks after Freezing Treatments, expressed in Disintegration Ratings. Data shown on 5 Sodium-Sulfate Treatments and 25 Actual Freezings.
Hard (1)	5820	662	No. 1...15.64 2...15.88 3...15.90 4...16.10 5...16.19 Av..15.94 1...15.80 2...15.88 3...15.90 4...16.02 5...16.13 Av..15.95	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............ A A A B B Actual Freezing Treatments. Number............ 5 10 15 20 25 Rating............ A A A A A
Medium (2)	5654	926	No. 1...16.28 2...16.45 3...16.45 4...16.70 5...16.70 Av..16.52 1...16.31 2...16.39 3...16.50 4...16.64 5...16.72 Av..16.51	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............ A A A B B Actual Freezing Treatments. Number............ 5 10 15 20 25 Rating............ A A A A A
Soft (3)	5710	622	No. 1...17.07 2...17.11 3...17.11 4...17.20 5...17.35 Av..17.17 1...17.00 2...17.02 3...17.15 4...17.35 5...17.35 Av..17.17	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............ A A B B C Actual Freezing Treatments. Number............ 5 10 15 20 25 Rating............ A A A A A

TABLE VII.—SAMPLE "E."

Process of Manufacture: Stiff Mud, Side Cut.

Kind of Clay: Red Shale.

Group and Makers Grade.	Compressive Strength on Edge, lb. per sq. in. (Mean of 5 Tests).	Modulus of Rupture, lb. per sq. in. (Mean of 5 Tests).	Absorption, per cent.	Condition of Bricks after Freezing Treatments expressed in Disintegration Ratings. Data shown on 5 Sodium-Sulfate Treatments and 25 Actual Freezings.					
Hard (1)	11 413	1 353	No. 1....2.76 2....5.11 3....6.28 4....6.59 5....6.63 Av...5.47	Sodium-Sulfate Treatments.					
				Number	1	2	3	4	5
				Rating	A	A	A	A	A
			1....3.10 2....5.55 3....6.16 4....6.27 5....6.35 Av...5.49	Actual Freezing Treatments.					
				Number	5	10	15	20	25
				Rating	A	A	A	A	A
Medium (2)	9 841	1 298	No. 1... 7.34 2... 7.89 3... 9.08 4... 9.58 5...10.55 Av.. 8.89	Sodium-Sulfate Treatments.					
				Number	1	2	3	4	5
				Rating	A	A	A	A	A
			1... 7.34 2... 8.06 3... 8.99 4... 9.50 5...10.55 Av.. 8.89	Actual Freezing Treatments.					
				Number	5	10	15	20	25
				Rating	A	A	A	A	A
Soft (3)	4 727	662	No. 1...15.68 2...16.01 3...16.68 4...16.37 5...17.70 Av..16.49	Sodium-Sulfate Treatments.					
				Number	1	2	3	4	5
				Rating	A	A	B	E	F
			1...15.71 2...16.03 3...16.60 4...16.72 5...17.41 Av..16.49	Actual Freezing Treatments.					
				Number	5	10	15	20	25
				Rating	A	A	A	A	B

TABLE VIII.—SAMPLE "F."

Process of Manufacture: Dry Press.

Kind of Clay: Surface Clay.

Group and Makers Grade.	Compressive Strength on Edge, lb. per sq. in. (Mean of 5 Tests).	Modulus of Rupture, lb. per sq. in. (Mean of 5 Tests).	Absorption, per cent.	Condition of Bricks after Freezing Treatments expressed in Disintegration Ratings. Data shown on 5 Sodium-Sulfate Treatments and 25 Actual Freezings.
Hard (1)	8784	667	No. 1...12.16 2...12.22 3...12.08 4...14.44 5...14.10 Av..13.00 1...12.15 2...12.12 3...14.00 4...13.63 5...13.70 Av..13.12	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............. A A A A A Actual Freezing Treatments. Number............ 5 10 15 20 25 Rating............. A A A A A
Medium (2)	4788	345	No. 1...16.25 2...16.78 3...17.42 4...17.35 5...16.78 Av..16.92 1...17.10 2...16.75 3...17.36 4...17.35 5...16.00 Av..16.91	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............. A A A B B Actual Freezing Treatments. Number............ 5 10 15 20 25 Rating............. A A A A A
Soft (3)	2822	258	No. 1...18.15 2...19.95 3...19.70 4...21.40 5...21.45 Av..20.13 1...18.26 2...19.65 3...19.95 4...21.55 5...21.03 Av..20.09	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............. A B B C C Actual Freezing Treatments. Number............ 5 10 15 20 25 Rating............. A A A A A

TABLE IX.—SAMPLE "G."

Process of Manufacture: Soft Mud, Repressed.
Kind of Clay: Surface Clay.

Group and Makers Grade.	Compressive Strength on Edge, lb. per sq. in. (Mean of 5 Tests).	Modulus of Rupture, lb. per sq. in. (Mean of 5 Tests).	Absorption, per cent.	Condition of Bricks after Freezing Treatments, expressed in Disintegration Ratings. Data shown on 5 Sodium-Sulfate Treatments and 25 Actual Freezings.					
Hard (1)	5865	1599	No.						
			1....6.06						
			2....5.91	Sodium-Sulfate Treatments.					
			3....7.66						
			4....7.52	Number............	1	2	3	4	5
			5....6.37	Rating............	A	A	A	A	A
			Av...6.70						
			1....7.74						
			2....6.72	Actual Freezing Treatments.					
			3....6.19						
			4....6.75	Number............	5	10	15	20	25
			5....6.10	Rating............	A	A	A	A	A
			Av...6.70						
Medium (2)	4884	1559	No.						
			1...12.38						
			2... 9.84	Sodium-Sulfate Treatments.					
			3...10.11						
			4...15.58	Number............	1	2	3	4	5
			5...13.66	Rating............	A	A	A	A	A
			Av..12.31						
			1...12.99						
			2... 9.25	Actual Freezing Treatments.					
			3...15.60						
			4...13.14	Number............	5	10	15	20	25
			5...10.66	Rating............	A	A	A	A	A
			Av..12.33						
Soft (3)	918	512	No.						
			1...24.61						
			2...27.17	Sodium-Sulfate Treatments.					
			3...27.60						
			4...24.27	Number............	1	2	3	4	5
			5...26.83	Rating............	B	C	D	F	F
			Av..26.10						
			1...27.50						
			2...24.75	Actual Freezing Treatments.					
			3...27.73						
			4...24.30	Number............	5	10	15	20	25
			5...26.20	Rating............	B	E	F	F	F
			Av..26.10						

latter 8 per cent were brick containing large quantities of lime in coarse particles, and that the disruptive effect of this lime slaking in water was probably more responsible for the disintegration than the actual freezing; presumably lime will slake more completely in water than in sodium-sulfate solution. Hence the apparent excess severity shown by the twenty-five water freezing treatments over the four sodium-sulfate treatments.

TABLE X.—SAMPLE "H."

Process of Manufacture: Soft Mud.
Kind of Clay: Surface Clay.

Group and Makers Grade.	Compressive Strength on Edge, lb. per sq. in. (Mean of 5 Tests).	Modulus of Rupture, lb. per sq. in. (Mean of 5 Tests).	Absorption, per cent.	Condition of Bricks after Freezing Treatments, expressed in Disintegration Ratings. Data shown on 5 Sodium-Sulfate Treatments and 25 Actual Freezings.
Medium (1)	5672	839	No. 1...14.01 2...15.22 3...15.38 4...15.46 5...15.21 Av. 15.06 1...14.32 2...15.10 3...15.21 4...15.23 5...15.45 Av..15.06	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............. A A A A A Actual Freezing Treatments. Number............ 5 10 15 20 25 Rating............. A A A A A
Soft (2)	4490	666	No. 1...17.13 2...17.76 3...17.90 4...18.37 5...17.49 Av..17.73 1...17.50 2...17.79 3...17.39 4...17.75 5...18.27 Av..17.74	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............. A A A C D Actual Freezing Treatments. Number............ 5 10 15 20 25 Rating............. A A A A A

The data at hand, therefore, seem to warrant the statement that four sodium-sulfate treatments will, in the vast majority of cases, subject a brick to a test as rigorous as twenty-five actual freezings under the conditions described above. In some cases it may be even more severe, but the error is on the safe side.

Correlation of Sodium-Sulfate Treatment with the Tentative Standard Test.—We have shown that the effect of the sodium-sulfate treatment is very much like that of actual freezing and that four treatments are equivalent to twenty-five freezings. We shall now attempt to compare the selective value of this test with the selective value of the tentative standard test. In Table XVII there are tabulated the thirty-seven groups according to their average compressive strengths, with the corresponding disintegration ratings (after four treatments) placed opposite them; and in Table XVIII the modulus of rupture has been tabulated in the same manner.

TABLE XI.—SAMPLE "I."

Process of Manufacture: Stiff Mud—End Cut.

Kind of Clay: Plastic Red Burning With Mixture of Some Buff Clay.

Hard (1)	6470	1302	No. 1...10.35 2...11.47 3...11.00 4...10.63 5...11.20 Av..10.93	Sodium-Sulfate Treatments.					
				Number	1	2	3	4	5
				Rating	A	A	A	A	A
			1...11.34 2...11.03 3...11.11 4...10.71 5...10.40 Av..10.92	Actual Freezing Treatments.					
				Number	5	10	15	20	25
				Rating	A	A	A	A	A
Soft (2)	1880	481	No. 1...22.51 2...22.20 3...21.79 4...20.92 5...20.05 Av..21.49	Sodium-Sulfate Treatments.					
				Number	1	2	3	4	5
				Rating	C	E	F	F	F
			1...22.00 2...21.00 3...22.40 4...21.49 5...20.15 Av..21.41	Actual Freezing Treatments.					
				Number	5	10	15	20	25
				Rating	D	F	F	F	F

From Table XVII, it is observed that thirty-three of the forty-six bricks rated below "C" were bricks below 4000 lb. per sq. in. compressive strength.

An examination of Table XVIII shows that there are no failures in brick having an average modulus of rupture greater

TABLE XII.—SAMPLE "J."

Process of Manufacture: Dry Press.

Kind of Clay: Red Burning Surface Clay.

Group and Makers Grade.	Compressive Strength on Edge, lb. per sq. in. (Mean of 5 Tests).	Modulus of Rupture, lb. per sq. in. (Mean of 5 Tests).	Absorption, per cent.	Condition of Bricks after Freezing Treatments, expressed in Disintegration Ratings. Data shown on 5 Sodium-Sulfate Treatments and 25 Actual Freezings.
Hard (1)	4093	727	No. 1...13.46 2...13.04 3... 9.91 4...10.61 5...12.55 Av..11.91 1...12.38 2... 9.74 3...13.28 4...10.97 5...13.20 Av..11.91	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............. A A A A A Actual Freezing Treatments. Number............ 5 10 15 20 25 Rating............. A A A A A
Medium (2)	2981	449	No. 1...16.63 2...15.83 3...16.29 4...16.61 5...16.98 Av..16.67 1...15.89 2...16.51 3...16.65 4...16.86 5...16.32 Av..16.45	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............. A A A A D Actual Freezing Treatments. Number............ 5 10 15 20 25 Rating............. A A B C D
Soft (3)	2063	335	No. 1...18.90 2...19.40 3...19.14 4...19.08 5...19.12 Av..19.13 1...18.94 2...19.60 3...18.90 4...19.39 5...18.83 Av..19.13	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............. B C E F F Actual Freezing Treatments. Number............ 5 10 15 20 25 Rating............. A B D F F

TABLE XIII.—SAMPLE "K."

Process of Manufacture: Soft Mud.

Kind of Clay: Surface Clay.

Group and Makers Grade.	Compressive Strength on Edge, lb. per sq. in. (Mean of 5 Tests).	Modulus of Rupture, lb. per sq. in. (Mean of 5 Tests).	Absorption, per cent.	Condition of Bricks after Freezing Treatments, expressed in Disintegration Ratings. Data shown on 5 Sodium-Sulfate Treatments and 25 Actual Freezings.
Hard (1)	20 830	1 884	No. 1... 3.70 2... 4.63 3... 4.64 4... 4.79 5... 5.30 Av.. 4.61 1... 4.16 2... 4.40 3... 4.41 4... 4.83 5... 5.27 Av.. 4.61	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............. A A A A A Actual Freezing Treatments. Number............ 5 10 15 20 25 Rating............. A A A A A
Medium (2)	14 136	1 272	No. 1... 7.94 2... 7.99 3... 8.45 4... 7.77 5...15.73 Av.. 9.78 1... 9.22 2... 8.92 3... 9.55 4... 9.95 5...11.06 Av.. 9.74	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............. A A A A A Actual Freezing Treatments. Number............ 5 10 15 20 25 Rating............. A A A A A
Soft (3)	5 452	767	No. 1...15.78 2...17.75 3...18.52 4...18.60 5...17.32 Av..17.59 1...17.30 2...17.00 3...17.54 4...17.95 5...18.15 Av..17.59	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............. B C D E F Actual Freezing Treatments. Number............ 5 10 15 20 25 Rating............. B B B C C

TABLE XIV.—SAMPLE "L."

Process of Manufacture: Soft Mud—Machine.

Kind of Clay: Surface Clay.

Group and Makers Grade.	Compressive Strength on Edge, lb. per sq. in. (Mean of 5 Tests).	Modulus of Rupture, lb. per sq. in. (Mean of 5 Tests).	Absorption, per cent.	Condition of Bricks after Freezing Treatments, expressed in Disintegration Ratings. Data shown on 5 Sodium-Sulfate Treatments and 25 Actual Freezings.
Hard (1)	2243	819	No. 1...18.81 2...19.20 3...19.80 4...20.09 5...20.30 Av..19.64 1...19.17 2...19.36 3...19.64 4...19.70 5...20.30 Av..19.63	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............. A A A B D Actual Freezing Treatments. Number............ 5 10 15 20 25 1 Gone Rating............. A A A A A
Medium (2)	3061	605	No. 1...20.68 2...20.69 3...21.79 4...21.80 5...21.92 Av..21.38 1...20.68 2...20.76 3...21.46 4...21.88 5...22.07 Av..21.37	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............. C D F F F F Actual Freezing Treatments. Number............ 5 10 15 20 25 Rating............. A A A A A
Soft (3)	2115	615	No. 1...22.66 2...22.96 3...23.90 4...23.99 5...25.35 Av..23.77 1...22.75 2...23.18 3...23.95 4...24.00 5...25.00 Av..23.78	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............. A B B E D D B F Actual Freezing Treatments. Number............ 5 10 15 20 25 1 Gone Rating............. A A A A A

TABLE XV.—SAMPLE "M."

Process of Manufacture: Soft Mud.
Kind of Clay: Surface Clay.

Group and Makers Grade.	Compressive Strength on Edge, lb. per sq. in. (Mean of 5 Tests).	Modulus of Rupture, lb. per sq. in. (Mean of 5 Tests).	Absorption, per cent.	Condition of Bricks after Freezing Treatments, expressed in Disintegration Ratings. Data shown on 5 Sodium-Sulfate Treatments and 25 Actual Freezings.
Hard (1)	6540	860	No. 1... 6.75 2... 8.10 3... 9.86 4... 11.30 5... 12.36 Av.. 9.67	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............ A A A A A
			1... 7.39 2... 8.51 3... 9.86 4... 10.32 5... 12.10 Av.. 9.64	Actual Freezing Treatments. Number............ 5 10 15 20 25 Rating............ A A A A A
Medium (2)	4808	1145	No. 1... 14.05 2... 14.06 3... 15.24 4... 16.65 5... 16.71 Av.. 15.34	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............ A A A A A
			1... 13.10 2... 14.41 3... 16.20 4... 16.26 5... 16.83 Av.. 15.37	Actual Freezing Treatments. Number............ 5 10 15 20 25 Rating............ A A A A A
Soft (3)	1793	387	No. 1... 17.20 2... 20.34 3... 21.75 4... 21.31 5... 23.48 Av.. 20.82	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............ A F F F F
			1... 17.55 2... 21.60 3... 21.30 4... 21.35 5... 22.30 Av.. 20.82	Actual Freezing Treatments. Number............ 5 10 15 20 25 Rating............ F F F F F

TABLE XVI.—SAMPLE "N."

Process of Manufacture: Soft Mud.

Kind of Clay: Surface Clay.

Group and Makers Grade.	Compressive Strength on Edge, lb. per sq. in. (Mean of 5 Tests).	Modulus of Rupture, lb. per sq. in. (Mean of 5 Tests).	Absorption, per cent.	Condition of Bricks after Freezing Treatments, expressed in Disintegration Ratings. Data shown on 5 Sodium-Sulfate Treatments and 25 Actual Freezings.
Hard (1)	3830	791	No. 1...18.73 2...19.39 3...18.86 4...20.35 5...20.43 Av..19.55	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............. A A A A B
			1...18.50 2...18.95 3...19.72 4...20.15 5...20.42 Av..19.55	Actual Freezing Treatments. Number............ 5 10 15 20 25 Rating............. A A A A A
Medium (2)	2048	551	No. 1...21.08 2...23.06 3...23.20 4...23.65 5...23.60 Av..22.92	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............. A A A A B
			1...21.24 2...22.60 3...23.20 4...23.72 5...23.80 Av..22.91	Actual Freezing Treatments. Number............ 5 10 15 20 25 Rating............. A A A A B
Soft (3)	1130	309	No. 1...24.48 2...24.65 3...26.50 4...26.20 5...26.30 Av..25.63	Sodium-Sulfate Treatments. Number............ 1 2 3 4 5 Rating............. A A B B C
			1...24.60 2...24.96 3...25.90 4...26.20 5...26.33 Av..25.60	Actual Freezing Treatments. Number............ 5 10 15 20 25 Rating............. A D E F F D

TABLE XVII.—COMPARISON OF COMPRESSIVE STRENGTH AND DISINTEGRATION RATINGS.

Mean Compressive Strength (on edge), lb. per sq. in.	Disintegration Ratings.					
	A.	B.	C.	D.	E.	F.
More than 15 000	5	..	..	..	..	..
15 000 -13 000	5	..	..	..	..	..
13 000 -11 000	10	..	..	..	..	..
11 000 - 9 000	10	..	..	..	..	..
9 000 - 7 000	5	1	1	3	..	..
7 000 - 5 000	20	15	..	..	5	..
5 000 - 4 000	15	5	5	..	5	..
4 000 - 3 000	5	..	5	5	..	5
3 000 - 2 500	5	..	5	..	..	..
2 500 - 2 000	5	7	5	..	3	5
2 000 - 1 500	..	..	..	..	..	10
1 500 - 1 000	..	5	..	..	..	..
Less than 1 000	..	..	..	..	..	5

TABLE XVIII.—COMPARISON OF MODULI OF RUPTURE AND DISINTEGRATION RATINGS.

Mean Modulus of Rupture, lb. per sq. in.	Disintegration Ratings.					
	A.	B.	C.	D.	E.	F.
1900 -1000	45	..	..	..	..	..
1000 - 800	10	5	..	..	..	..
800 - 700	10	..	..	5	5	..
700 - 600	5	5	5	5	5	5
600 - 500	10	7	..	5	..	8
500 - 400	5	..	..	..	..	5
400 - 300	..	10	5	..	..	10
300 - 200	..	..	10	..	..	..

than 800 lb. per sq. in.; but as several failures occur in the interval between moduli of 800 and 500 lb. per sq. in., we must conclude that the sodium-sulfate treatment would rule out a good many brick whose modulus of rupture would place them in the hard and medium classes. It is to be noted that all failures in this interval are bricks of high absorption, the range being from 16.5 to 24 per cent, which throws them all into the medium and soft brick classifications by the A. S. T. M. tentative standards. On the other hand, the average compressive strengths by groups are 8828, 5452, 5710, 4727, 4490, 3061, 2115, 3610, and 918 lb. per sq. in.; showing that by the compressive strength alone, six of the nine groups would be passed as hard brick. We see then that the sodium-sulfate treatment rules against these brick, while they are passed as hard brick by the compression test and fall into the medium and soft brick classes by the absorption test. These facts are mentioned here because they indicate the ability of the sodium-sulfate test to discriminate at once between degrees in quality that are not brought out by the other individual tests, where bricks require the combination of absorption, compression, and transverse tests before they can be classified where they belong. This is not a criticism of the A. S. T. M. tentative standard, but a favorable comment on the sodium-sulfate test. In Table XIX the data are so arranged as to show a comparison between the grading of thirty-seven groups, (1) by the A. S. T. M. tentative specifications, and (2) by the sodium-sulfate freezing process.

SPECIFICATIONS PROPOSED TENTATIVELY FOR GRADING BY THE SODIUM-SULFATE PROCESS.

Using the symbols before given to express the relative degrees of disintegration, and considering that symbol B stands for very slight superficial disintegration without cracking, and that symbol C stands for only such cracks as have given no evidence of internal weakness, it is proposed to approve or pass any sample which after four tests will show:

1. Three or more A's with the others not below C.
2. Five bricks not less than B, and to fail all others.[1]

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[1] The tentative specifications proposed by the author in his paper (*Transactions*, Am. Ceramic Soc., Vol. 18), passed only those bricks falling in item 1 of the present specification, but a study of the concurrent actual freezing tests seems to warrant the addition of item 2.

A study of Table XIX shows that of the seventeen groups ranked as A in the four sodium-sulfate treatments, all but two are unaffected by the twenty-five actual freezings. The two groups just mentioned are J-2, and N-2. The former is destroyed by actual freezing and the latter is slightly affected, ranking in grade B. Of the seven groups ranked as B in the sodium-sulfate tests, all but one group have passed the twenty-five actual freezings without apparent attack; the one exception being group N-3, which is commented upon in the discussion of Table XIX. This indicates that only in exceptional cases will twenty-five actual freezings administer a more searching test than four sodium-sulfate treatments.

It is observed from Table XIX that there is a remarkable concordance between the verdict of the sodium-sulfate tests and those of the A. S. T. M. specifications. In all of the nine cases, the products rated "vitrified" and "hard" by A. S. T. M. tests are passed by the sodium-sulfate test. There are fifteen groups rated "medium" by the A. S. T. M. test, of which four groups are failed by the sodium-sulfate tests. There are twelve groups rated "soft" by the A. S. T. M. tests, of which all but three groups are failed by the sodium-sulfate tests. One group J-2, passed by the A. S. T. M. and sodium sulfate, is failed by actual freezing.

Commenting on these instances of non-agreement between the ratings of the two methods:

The Hard Class shows perfect agreement of ratings by the two methods within the scope of this work.

The Medium Class.—Group E-3, rated "medium" by the A. S. T. M. tests, is failed by the sodium-sulfate test and is slightly affected by twenty-five actual freezings. This group consists of stiff-mud shale bricks submitted by the manufacturer as underburned. They show an average absorption of 16.5 per cent, whereas the groups submitted by the manufacturer as "medium" and "hardburned" show 9 and 5.5 per cent respectively. In this case the sodium-sulfate test has made a very definite attack upon a group which might be represented as a safe brick for exterior use, if judged only by its behavior in the A. S. T. M. tests, but which would be pronounced unsafe for exterior work when the facts about its manufacture and the

TABLE XIX.—COMPARISON BETWEEN THE GRADING OF 37 GROUPS OF 5 BRICKS EACH.

1. By the A.S.T.M. Tentative Standard Specifications.
2. By Tentative Specifications for Sodium-Sulfate Freezing Process.

Sample Designation.	Absorption, per cent.		Compressive Strength, lb. per sq. in.		Modulus of Rupture, lb. per sq. in.		Sodium-Sulfate Tests: Disintegration Ratings for Fourth Treatment.						Actual Freezing.	A. S. T. M. Rating.	Sodium-Sulfate Test-Rating.
	Mean for Group.	Individual Maximum.	Mean for Group.	Individual Minimum.	Mean for Group.	Individual Minimum.	A.	B.	C.	D.	E.	F.			
K-1	4.61	5.30	20830	18600	1884	1570	5	..	..	..	..	..	A	Vitrified	Pass
E-1	5.47	6.63	11413	9050	1353	1030	5	..	..	..	..	..	A	Hard	"
G-1	6.70	7.66	5865	4470	1599	1249	5	..	..	..	..	..	A	"	"
E-2	8.89	10.55	9841	8650	1298	877	5	..	..	..	..	..	A	"	"
M-1	9.67	12.36	6540	3430	860	640	5	..	..	..	..	..	A	"	"
K-2	9.78	15.73	14136	4570	1272	782	5	..	..	..	..	..	A	"	"
I-1	10.93	11.47	6470	5340	1302	1100	5	..	..	..	..	..	A	"	"
A-1	11.88	12.44	11248	9000	1311	1245	5	..	..	..	..	..	A	"	"
J-1	11.91	13.46	4093	3015	727	556	5	..	..	..	..	..	A	"	"
G-2	12.31	15.58	4884	4430	1559	876	5	..	..	..	..	..	A	Medium	"
F-1	13.00	14.44	8784	6390	667	525	5	..	..	..	..	..	A	"	"
H-1	15.06	15.46	5672	4660	839	681	5	..	..	..	..	..	A	"	"
M-2	15.34	16.71	4808	3540	1145	573	5	..	..	..	..	..	A	"	"
C-1	15.91	17.47	9350	7990	615	504	5	..	..	..	..	..	A	"	"
D-1	15.94	16.19	5820	5280	662	466	..	5	..	..	..	..	A	"	"
E-3	16.49	17.70	4727	3620	662	549	..	..	..	..	5	..	B	"	Fail
D-2	16.52	16.70	5654	4696	926	580	..	5	..	..	..	..	A	"	Pass
J-2	16.67	16.98	2981	2571	449	369	5	..	..	..	..	..	D	"	"
D-3	17.17	17.35	5710	3590	622	385	..	5	..	..	..	..	A	"	"
K-3	17.59	18.15	5452	2500	767	695	..	..	..	..	5	..	C	"	Fail
H-2	17.73	18.37	4490	3160	666	592	..	..	5	..	..	..	A	"	"
N-1	19.55	20.43	3830	3235	791	690	5	..	..	..	..	..	A	"	Pass
L-1	19.64	20.30	2243	1125	819	469	..	5	..	..	..	..	A	"	"
C-2	20.20	20.93	8828	8470	788	609	..	..	..	5	..	..	A	"	Fail
F-2	16.92	17.42	4788	4180	345	258	..	5	..	..	..	..	A	Soft	Pass
A-2	18.55	18.91	3588	2890	348	310	..	..	5	..	..	..	A	"	Fail
B-1	18.97	19.70	3610	2860	554	276	..	..	..	5	..	..	B	"	"
J-3	19.13	19.60	2063	1890	335	309	..	..	..	..	..	5	F	"	"
F-3	20.13	21.45	2822	2100	258	108[a]	..	..	5	..	..	..	A	"	"
A-3	20.40	20.70	2062	1590	289	225	..	..	5	..	..	..	A	"	"
M-3	20.82	23.42	1793	1240	387	235	..	..	..	..	..	5	F	"	"
L-2	21.38	21.92	3061	1658	605	268	..	..	..	..	..	5	A	"	"
I-2	21.49	22.51	1880	1460	481	394	..	..	..	..	..	5	F	"	"
N-2	22.92	23.60	2048	1300	551	417	5	..	..	..	..	..	B	"	Pass
L-3	23.77	25.35	2115	1945	615	350	..	2	..	..	3	..	A	"	Fail
N-3	25.63	26.50	1130	845	309	188	..	5	..	..	..	..	F	"	Pass
G-3	26.10	27.60	918	610	512	342	..	..	..	..	..	5	F	Unclassifiable	

[a] Modulus of rupture is too low for soft class.

relation it bears to the mormal product of the same shale are known. These bricks are of homogeneous structure and are good samples of well-made stiff-mud brick. The ability of the sodium-sulfate process to apply a more rigorous test in four treatments than is accomplished by twenty-five actual freezings, is brought out nicely in this group. It is to be noted that the bricks in question are free from noticeable particles of lime or other foreign substance, which is in contrast to the conditions in groups J-2, H-2, and C-2, described below.

Group K-3, rated "medium" by the A. S. T. M. tests, is failed by the sodium-sulfate test and also by the actual freezing. This group consists of soft-mud bricks submitted by the manufacturer as underburned product. The groups submitted by him as "medium" and "hard-burned" show remarkable physical strength, their compressive strength being 14,000 and 20,000 lb. per sq. in. respectively, while their moduli of rupture are 1272 and 1884 lb. per sq. in. respectively. It is not surprising, therefore, that even the soft-burned samples show a very fair compressive strength and modulus of rupture, 5400 and 767 lb. per sq. in. respectively. But—and here is the special value of the sodium-sulfate test—the structure is evidently not sufficiently resistent to those peculiar disruptive forces exerted by freezing to warrant the use of these brick for exterior work.

Group J-2, rated "medium" by the A. S. T. M. tests and passed by the sodium-sulfate test, is failed by twenty-five actual freezings. This group consists of well-made dry pressed bricks. The structure showed a great number of grains of lime in various stages of fineness, thoroughly distributed throughout the mass. This lime, although dead-burned in the J-1 group (manufacturer's hard sample) is not dead-burned in the group in question. The probable explanation of the fact that failure did not occur in the four sodium-sulfate treatments is that grains of lime will not slake as completely or as rapidly in a nearly saturated sodium-sulfate solution as in clear water. Therefore, the forces set up by the slaking of the lime during the actual freezing tests were not present to the same degree in the sodium-sulfate tests. The beginning of attack, however, was noticed in the fourth treatment and the fifth treatment caused the brick to fail, falling into the D class. This group is an example of the kind of bricks which are not accurately classified by the four sodium-sulfate treatments recommended above. Further comment will be made on lime-bearing bricks in the conclusions to be drawn from this work.

Group H-2, rated "medium" by the A. S. T. M. tests is failed by the sodium-sulfate test but is not affected by twenty-five actual freezings. This is a soft-mud product made from poorly prepared clay. There are a good many flinty pebbles scattered through the mass of the bricks. It is along the lines of accidental weakness of structures caused by these stones, and by the poor bond between them and the clay matrix, that failure has occurred. Here the sodium-sulfate test has brought out a weakness due to a lack of homogeneity and the presence of foreign material that would not be shown by the A. S. T. M. tests, or by twenty-five actual freezings.

Group C-2, rated "medium" by the A. S. T. M. tests, is failed by the sodium-sulfate test but is unaffected by twenty-five actual freezings. These are soft-mud bricks of fairly homogeneous material but poorly prepared. The bricks fail along lines of structural weakness and break into bats and chunks that retain considerable strength throughout the test. In this group, as in the case of groups E-3 and H-2 above, the sodium-sulfate test is more rigorous than twenty-five actual freezings, but in all these cases of failure the weakness of structure is indisputable and would no doubt be demonstrated by actual freezing tests if they could be repeated often enough.

Soft Class.—Groups rated "soft" by the A. S. T. M. tests would be expected to fail by the sodium-sulfate test. There are, however, three groups so rated that are passed by the sodium-sulfate test. They are as follows:

Group F-2, rated "soft" by the A. S. T. M. tests, is passed by the sodium-sulfate test, being only slightly attacked. It is unaffected by twenty-five actual freezings. This group consists of dry-pressed brick and is shown by the tests to be on the border line between the medium class and the soft class. A slightly better modulus would advance it to the medium class, while a fifth sodium-sulfate treatment causes unmistakable failure. In this particular case some evidence other than that elicited by the tests may be permitted. It is known that this grade of dry-pressed brick from this particular plant has been used for general exterior construction in the St. Louis district for more than twenty-five years; this would seem to verify the justice of the sodium-sulfate verdict of "pass."

Group N-2, rated "soft" by the A. S. T. M. tests, is passed by the actual freezing tests. This group consists of soft-mud brick made from clay containing large quantities of lime present in lumps up to ½ in. in diameter. This lime, however, seems to be dead-burned and although contributing largely to the low compressive and transverse strength of the brick, it does not seem to be an element of serious weakness in the freezing test. It shows no evidence of hydration in the repeated soaking in clear water occasioned during the actual freezing tests and the thawing treatment following each freeze. The strength of the true burned clay matrix is good and is not affected by the sodium-sulfate treatment.

Group N-3, rated "soft" by the A. S. T. M. tests, is passed by the sodium-sulfate test but failed completely in the actual freezing. This group is made by the soft-mud process and consists of the same raw material as in group N-2, containing large particles of lime that apparently have not been dead-burned. This lime contributes to the weakness as shown by the compression and transverse tests, and being capable of hydration, it is doubtless responsible for the failure of the group during the actual freezing test. In fact, the bricks broke into pieces along lines of weakness caused by the lime pebbles, while these pieces themselves were apparently unaffected by the freezing test. This indicates that the failure was caused more by the localized strains due to hydration of the lime, than by disruptive forces created throughout the structure of the brick. Here again, as in group J-2, the probable explanation of the fact that failure did not occur in the four sodium-sulfate treatments is that lumps of lime will not slake completely in a nearly saturated sodium-sulfate solution, so that the forces set up by the slaking of the lime during actual freezing were not present to the same degree in the sodium-sulfate tests. The beginning of attack was noticed on the fourth treatment, but the bricks did not fail until the fifth treatment. These bricks deserve to be condemned and as a matter of fact would be condemned by visual inspection. No brick containing large kernels of quicklime should be approved for exterior work. That the sodium-sulfate test did not destroy them in four treatments is no serious criticism of its usefulness in the vast majority of cases. We are seeking a method for testing the bulk of material as found on the market today, bricks having a fair degree of homogeneity, that will pass a rigid enough visual inspection to warrant further tests of their properties. To all such cases, within the limits of this work, it has applied with surprising fitness.

SUMMARY.

Concerning the value of the A. S. T. M. tentative tests and the proposed sodium-sulfate tests, after giving due consideration to the light shed upon each test by the other, and upon both tests by the actual freezing, the following statements seem warranted:

1. But one group of all tested falls into the vitrified class. These are well-made soft-mud brick of exceptional strength. No broad statement can be made from the study of one group, but we believe that the A. S. T. M. test will be reliable for vitrified brick.

2. The A. S. T. M. tests are thoroughly reliable for selecting hard brick.

3. The A. S. T. M. tests are reliable in most cases in selecting or classifying medium bricks that will endure exposure in exterior walls. There are, however, exceptional cases where they are not rigorous enough. For example: Group E-3, underburned shale brick; group K-3, underburned soft brick of such structure that it will withstand considerable compressive and transverse strains, but will not withstand those peculiar disruptive forces set up by freezing; group H-2, bricks containing large lumps of foreign material of radically different properties from burned clays. In this case the foreign material consists of flint pebbles; the bond between such material and the clay matrix is weakened by freezing and causes failure, although it may have enough initial strength to pass the compressive and transverse requirements.

4. The thoroughness with which the A. S. T. M. tests

select the soft bricks, that is, bricks unsuitable for exterior work, is commendable indeed. If it errs at all it is on the safe side. An occasional exception is found, as for example group F-2, which will probably stand the weather. These tests seek out weaknesses due to presence of soft foreign material, such as lime, and weaknesses due to cracks and checks, with equal readiness.

5. We believe that the limits of absorption, compressive, and transverse strength assigned to each class are well chosen, and no suggestions for changes are offered.

6. The sodium-sulfate test is a useful and reliable test. It is easy to keep all conditions of the test within limits that will ensure very small variations of concentration of the salt solution. It requires but a short time, eight days for four treatments, and the equipment needed is such that it can be obtained almost anywhere. In applying this test to thirty-seven groups of brick there are but two instances where its verdict may be said to be grossly misleading: groups J-2 and N-3, both containing large quantities of lime and both of high absorption.

As a safeguard against the inability of this test to equal actual freezing in those particular cases where the bricks contain large quantities of lime, and where the disrupting forces are due largely to complete hydration of the lime, it is recommended that the four sodium-sulfate treatments be supplemented by five hours boiling in water, after the fourth treatment. This will give any unslaked lime an opportunity to slake and exert its disruptive forces upon the burned clay matrix that has already been pretty thoroughly tested by the sodium-sulfate treatment. We believe that with this precaution this test can be depended upon to classify building bricks into those which will endure exposure to freezing, and those that will not.

7. We believe that if a sample of bricks will pass the sodium-sulfate test herein recommended, and is within the limits of absorption set by the A. S. T. M. standard for vitrified brick, it is safe to classify them as vitrified brick without knowledge as to their compressive and transverse strengths.

8. We believe that a sample of bricks which will pass the sodium-sulfate test and lie within the absorption limits set by the A. S. T. M. standards for medium brick, may be safely

classed as medium brick, without knowledge of their compressive and transverse strengths.

9. The facts seem also to warrant the statement that if a sample of brick fails by the sodium-sulfate test, it may safely be classed as a soft brick without knowledge of its compressive and transverse strengths, and regardless of its absorption, unless that absorption is lower than the limits set for soft brick by the A. S. T. M. standards.

10. Emphasis must be given to the absolute necessity of carrying out the sodium-sulfate test in the manner described above, for a considerable variation in the severity of the successive treatments by any one operator or in the tests made by the different operators is liable to result from a change in the method of using the solution. The crystallization must take place rapidly and in an oven at temperatures between 110 and 120° C. to insure the formation of the anhydrous sodium-sulfate crystal. If crystallization is allowed to take place slowly at room temperature, the decahydrate sodium-sulfate crystal, $Na_2SO_4 \cdot 10H_2O$ will be formed. This salt has a much larger volume than the anhydrous crystal and hence exerts a much more severe force upon the structure of the sample. For this reason it is essential that each treatment be followed promptly by the next treatment in order not to allow time for the formation of the hydrous salt, as such action will vitiate the test. This is demonstrated by the fact that several of our samples disintegrated due to the formation of this crystal, upon being allowed to stand in the open in the work room, after successfully passing the five sodium-sulfate treatments as described.

11. The facts brought out in the last paragraph will explain why some persons who have attempted to apply this test without the use of an oven have found it variable and too severe.

12. The objection offered by some that the sodium-sulfate test is more severe than actual freezing is admitted to be true, for we have found that in most cases four sodium-sulfate treatments are more than equivalent to twenty-five actual freezings. The fact is worthy of emphasis, however, that a factor of safety is allowed in practically all other structural materials such as steel, wood and concrete, and that it is equally desirable in brick. If a brick will pass the sodium-sulfate test herein pre-

scribed and is not so full of lime pebbles that it deserves rejection by visual inspection, we may be reasonably certain that it will give good service in an exterior wall exposed to repeated freezings. We therefore commend this test to the consideration of the Society.

CONCLUSIONS.

1. It is recommended that the specifications for the testing of building bricks be amended to include the sodium-sulfate test or the ice-freezing test, or both. The former should be carried out substantially as described in this paper.

2. It is recommended that the specifications for the basis of classification of building bricks be based principally upon the standing of the bricks in the absorption and sodium-sulfate test (four treatments). The following classification of building bricks into four grades is suggested:

Name of Grade.	Absorption Limits, per cent.		Sodium-Sulfate Test (Four Treatments).
	Mean of 5 Tests.	Individual Maximum.	
Vitrified Brick...	5 or less.	6	Grading A only.
Hard Brick.....	5–12	15	Grading A with none lower than B, and not more than two of that grade in five bricks.
Medium Brick...	12–20	24	Grading A or B with none lower than C, and not more than two of that grade in five.
Soft Brick.......	Above 20	No limit.	Unable to stand C or better.

Any sample unable to meet both tests falls automatically to that grade to which its worse report consigns it.

If, for instance, a sample lot of five bricks showing 8 per cent absorption is graded two C and three B by the sodium-sulfate test, it would be classified as "medium." If a sample lot showed 14 per cent absorption and a sulfate test report of two C and three D, it would rank as "soft." If the lot showed 22 per cent average absorption and still passed the sulfate test with five A, it would remain "soft" on account of the high absorption.

3. The results of the compression or modulus-of-rupture

tests should not disqualify a brick from its rating as determined under paragraph 2. In fact, it might be feasible to dispense with the mechanical test entirely.

4. Rejection on visual inspection on account of coarse pebbles or marked irregularity of structure may be applied to bricks of the three better grades. Marked inhomogeneity in bricks otherwise graded as "soft" shall not disqualify for use in that grade.

The author desires to express his indebtedness and appreciation to Mr. Ellsworth Ogden for the very satisfactory execution of the laborious work involved in this series of tests.

REPORT OF COMMITTEE C-4
ON
CLAY AND CEMENT SEWER PIPE.

Since the last annual report was issued Committee C-4 has held two meetings at which were considered the reports of the several sub-committees.

Additional information has been obtained through the performance of crushing, hydrostatic and absorption tests. Further consideration has also been given to the dimensions of pipes and their permissible variations. Additional studies along all these lines are being carried on and proposed revisions to the present tentative specifications will be considered at meetings to be held during the approaching annual meeting of the Society.

The committee recommends that the Tentative Specifications for Clay Sewer Pipe (C 13–18 T), the Tentative Specifications for Cement-Concrete Sewer Pipe (C 14–18 T) and the Tentative Specifications for Required Safe Crushing Strengths of Sewer Pipe to carry Loads from Ditch Filling (C 15–17 T,)[1] be continued as tentative for another year.

The committee further recommends that the Tentative Recommended Practice for Laying Sewer Pipe (C 12–17 T)[2] be submitted to the Society for adoption by letter ballot as "Recommended Practice."

This report has been submitted to letter ballot of the committee, which consists of 22 members, of whom 13 have voted affirmatively, 6 negatively, and 3 have refrained from voting.

Respectfully submitted on behalf of the committee,

RUDOLPH HERING,
Chairman.
A. J. PROVOST, JR.,
Vice-Chairman.

G. T. HAMMOND,
Secretary.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part I, pp. 542 ff. (1918).
[2] *Ibid.*, p. 612.

ADDENDUM

TO

REPORT OF COMMITTEE C-4.

The committee recommends the following revisions in the Tentative Specifications for Cement-Concrete Sewer Pipe (C 14–18 T),[1] which were approved at a meeting of the committee held during the annual meeting of the Society. Since there has not been an opportunity to refer these revisions to a letter ballot vote of the committee, it is recommended that they be accepted subject to a favorable vote of the committee by letter ballot subsequent to the annual meeting.

PROPOSED REVISIONS IN SPECIFICATIONS FOR CEMENT-CONCRETE SEWER PIPE.

1. Change the third and fourth paragraphs of Section 16 on "Hydrostatic Test" to read as follows:

> "Water pressures, as measured by a standardized gage attached to the delivery pipe close to the specimen, shall be internally applied to the specimens as follows:
>
> 5 lb. per sq. in. for 5 minutes;
> 10 lb. per sq. in. for 10 minutes;
> 15 lb. per sq. in. for 15 minutes;
>
> The specimens shall show no leakage under these pressures. Moisture appearing on the surface of the pipe in the form of patches or beads, adhering to the surface, shall not be considered leakage."

2. In Table II on "Physical Test Requirements," insert a value of 8 per cent as the maximum allowable absorption.

3. Make the following changes in Table III on "Dimensions":

> (*a*) Change the values in the third column to agree with those in the third column of Table III of the Tentative Specifications for Clay Sewer Pipe (C 13–18 T).

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part I, pp. 555–566 (1918).

(*b*) Strike out the fourth column of the table entitled "Normal Annular Space."

(*c*) Strike out the word "minimum" from the heading of the seventh column.

(*d*) Add a column to the table reading, "The thickness of the socket $\frac{1}{4}$ in. from its outer end shall not be less than three-quarters of the thickness of the barrel of the pipe."

(*e*) Add the following letters to the seven columns remaining in the table as thus revised, beginning with the first column at the left:

$$D, L, D_s, L_s, H, T, T_s,$$

and add a sketch showing the points at which the dimensions apply, lettered so as to correspond with the letters in the column headings of the table.

4. In Section 27, change the first sentence to read as follows by the omission of the words in brackets and the addition of the italicized words:

> "Pipes shall be furnished of the sizes, internal diameter, and with the [minimum] dimensions given in [Table] *Tables* III *and IV*"

Respectfully submitted on behalf of the committee,

RUDOLPH HERING,
Chairman.

EDITORIAL NOTE.

The Tentative Recommended Practice for Laying Sewer Pipe referred to in this report was approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1919, and appears in the Supplementary Pamphlet of A.S.T.M. Standards Adopted in 1919.

The proposed revisions in the Tentative Specifications for Cement-Concrete Sewer Pipe included in the addendum to the report were approved by a subsequent letter ballot vote of the committee. The specifications have accordingly been revised as indicated and appear in their revised form on pages 556–568.

REPORT OF COMMITTEE C-6

ON

DRAIN TILE.

Committee C-6 completed and thoroughly revised the Standard Specifications for Drain Tile in 1916. Since their adoption in that year these specifications have been distributed widely and seem to have come into use by drainage engineers extensively.

Practically no criticisms have been received from practicing engineers as yet.

However, the committee believed that further study and investigation were advisable of two points in the 1916 specifications as follows:

1. The chemical requirements, especially as regards concrete tile and with reference to the effect of alkali soils upon concrete tile;
2. The freezing and thawing test, because of the newness of the methods and requirements specified.

The United States Bureau of Standards has been conducting extensive investigations on the first of these questions and Mr. G. M. Williams, of the Bureau of Standards, has been elected to membership on Committee C-6 in order that the data obtained in the investigation of the Bureau of Standards might be made available more effectively by Committee C-6.

The Iowa Engineering Experiment Station has been conducting extensive investigations on freezing and thawing tests of drain tile, especially surface clay and concrete drain tile, and has obtained a mass of data which are yet to be considered by the committee.

In February, 1919, the chairman of Committee C-6 prepared historical and other data on the Standard Specification for Drain Tile as called for by the Assistant Secretary of the Society, in order that the representatives of the Society might present these specifications to the recently organized American

Engineering Standards Committee for consideration for possible adoption as one of the American Tentative Standard Specifications.

No meeting of Committee C-6 was held during the year, but one will be held during the coming annual meeting.

This report has been referred to letter ballot of the committee, which consists of 15 members, of whom 12 have voted affirmatively, 0 negatively, and 3 have refrained from voting.

Respectfully submitted on behalf of the committee,

ANSON MARSTON,
Chairman.

REPORT OF COMMITTEE C-7

ON

LIME.

In pursuance of instructions from the Executive Committee, Committee C-7 was completely reorganized and held its first regular meeting in Philadelphia, September 13, 1918, with Mr. C. L. Warwick, Acting Secretary of the Society, present, for whose attendance, interest and guidance the committee here records its appreciation.

The reorganization was accomplished by the adoption of by-laws, election of officers and the appointment of sub-committees, and the committee now consists of 21 members of whom seven are recent additions to the membership of the Society.

Since the meeting in September three other meetings of the committee have been held, two in Washington and one in Philadelphia, the average attendance being thirteen In addition, a number of meetings of the various sub-committees have been well attended.

Sub-Committees.—Sub-committees are energetically at work, their activities in connection with the various uses of lime being indicated by their titles, as follows:

I. Coordination
II. Structural Lime
III. Agricultural Lime
IV. Chemical Lime
V. Chemical Analysis
VI. Plasticity
VII. Highway Lime

The activities of these sub-committees make up the principal subject matter of this report. It will be seen that some of the work has been completed and has resulted in certain recommendations on the part of the main committee.

Structural Lime.—The Sub-Committee on Structural Lime is conducting an investigation looking toward the development of a standard sand for laboratory tests of lime; the development of standard methods for the measurement of sand-carrying capacity and yield of lime, and the development of standards of practice for slaking differing limes. It is also formulating lines of investigation to determine the general practice, characteristics, and behavior of lime in the mixing and aging of mortars and plasters. To this end it has secured the Codes and Building Laws of all principal cities of this country, some of those overseas, and in addition, is receiving the cooperation of the U. S. Bureau of Standards, the Lime Association, the Operative Plasterers and Cement Finishers International Association of the United States and Canada, and other organizations.

The committee has also taken steps toward cooperation with Committee C-11 on Gypsum on questions of nomenclature, and on the use of mixtures of lime and gypsum for the finishing coat of wall plaster; with Committee C-1 on Cement on the use of lime in cement mortar, and with Committee C-9 on Concrete and Concrete Aggregates on the use of hydrated lime in concrete.

The sub-committee has proposed the following method for the determination of the fineness of hydrated lime, which the committee has adopted by the following letter ballot vote: affirmative, 11; negative, 1; not voting, 9; and recommends that it replace the present method for determining fineness in the Tentative Specifications for Masons' Hydrated Lime (C 6–17 T).[1]

> "Fineness of hydrated lime shall be determined as follows:
>
> Place 100 g. of the sample as received on a standard 30-mesh sieve having openings averaging 0.0198 in. This sieve shall be nested above a standard 200-mesh sieve having openings averaging 0.0029 in. Wash the material by means of a stream of water from a faucet. A small piece of rubber tubing attached to a water faucet will be found convenient. The velocity of the stream of water can be increased by pinching the tubing, but it should not be sufficient to cause any danger of splashing the sample over the sides of the sieve. Continue the washing until the water coming through the sieve is clear. Then dry the residue upon the 30-mesh sieve to constant weight in a drying oven whose temperature is maintained between 100 and 120° C. in an atmosphere free from carbon dioxide. Calcu-

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part I, p. 569 (1918).

> late the weight of this residue as percentage of the original sample. Then wash the material which has passed the 30-mesh sieve and remained on the 200-mesh sieve through the latter as described above. Treat the residue on this sieve in the same manner as described above for the 30-mesh sieve and add the percentage retained to the percentage residue on the 30-mesh sieve. The sum of these two shall be reported as the residue on the 200-mesh sieve."

While the committee is in favor of continuing the limits of fineness as expressed in the present Tentative Specifications for Masons' Hydrated Lime, certain changes have been suggested by members of the committee and these are now being investigated.

In view of the fact that the durability of wall plaster depends largely upon the methods of application, as well as upon the properties of the lime and its correct admixture with appropriate materials composing plaster, this sub-committee is working upon specifications for interior plastering for later submission to the society.

Agricultural Lime—The Sub-Committee on Agricultural Lime has decided that the term "agricultural lime" includes any material containing either the radical calcium oxide or a mixture of calcium and magnesium oxide in any of the forms of oxide, hydrate or carbonate. This sub-committee has further decided that the magnesium oxide is at least equally as valuable as calcium oxide for agricultural purposes.

In cooperation with the Lime Association, this sub-committee is now investigating the fineness, solubility, purity, distribution, and availability of pulverized limestone.

Chemical Lime—The Sub-Committee on Chemical Lime has learned that a loss approximating $150,000,000 occurred to the citizens of the United States during the war, due to an inadequate understanding of the properties and qualities of the lime used as a chemical reagent in manufacturing industries. This has impressed upon the sub-committee the importance of determining the qualities and characteristics of lime which will best meet the needs of each particular industry. The sub-committee now has on its list 116 different industries which are being studied. These studies will be conducted as far as possible through cooperation with technical societies of the industry involved.

Chemical Analysis.—Most of the work of the Sub-Committee on Chemical Analysis has been completed. Tentative Methods for Chemical Analysis of Limestone, Lime and Hydrated Lime, appended to this report,[1] have been adopted by the following letter ballot vote of the committee: affirmative, 9; negative, 0; not voting, 12; and the committee recommends that the methods be published by the Society as tentative.

A few minor matters such as methods for determining phosphorus, manganese, etc., are now being developed.

Plasticity.—The Sub-Committee on Plasticity has proposed the following definition of "plasticity:"

> "*Plasticity* is that property of a material, or combination of materials, by virtue of which it deforms continuously and permanently during the application of force."

The committee has adopted this definition by a letter ballot vote of 12 affirmative, 2 negative, and 7 not voting, and submits it to the Society with the request that it be considered during the year by other committees of the Society which are concerned with this property of materials.

The sub-committee also has designed an instrument for the measurement of this property. This instrument is now being used by the U. S. Bureau of Standards. A program for field tests will supply information as to the value of the results obtained with this instrument.

A petrographic study is also being made to obtain further light on the probable causes which contribute to the plasticity of lime.

Highway Lime.—The work of the Sub-Committee on Highway Lime was inaugurated by an inspection of the hard surfaced roads in which hydrated lime was used in the State of Delaware. This will be followed by an active program to develop the value of lime for this purpose.

The committee has adopted the following resolution which tsrie pectfully refers to the Executive Committee of the Society:

> "That, whereas, sand is a material used broadly for construction purposes, and, whereas, nearly all of the 'Group C' committees of the Society are interested in, and have to deal with the question of sand as an admixture

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[1] See pp. 597–604.—ED.

with the material over which each committee has jurisdiction, the Executive Committee be requested to instruct all standing committees interested in sand to elect sub-committees on this material; and that the Executive Committee be requested to create a standing Committee on Sand to be composed of one delegate from each of the above mentioned sub-committees."

The committee wishes further to suggest the desirability of the adoption by the Society of standard testing sieves promulgated by the Bureau of Standards. It is appreciated that the 200-mesh sieve has been carefully standardized in the Specifications and Tests for Portland Cement and that standards for certain meshes have also been adopted by the Society for use in road material work;[1] and the committee believes that this work might well be extended to cover the adoption of standard sieves for all purposes.

Committee C-7 accepts this opportunity to extend to the Executive Committee its appreciation of the opportunity afforded it to be of service to the Society and to the producers and all users of lime through the Executive Committee's decision to reorganize the committee.

This report has been submitted to letter ballot of the committee, which consists of 21 members, of whom 18 have voted affirmatively, 0 negatively, and 3 have refrained from voting.

Respectfully submitted on behalf of the committee,

D. KNICKERBACKER BOYD,
Chairman.

NORMAN G. HOUGH,
Secretary.

EDITORIAL NOTE.

The proposed revision in the Tentative Specifications for Masons' Hydrated Lime referred to in this report was approved and the specifications in their revised form appear on pages 571–574.

The proposed Tentative Methods for Chemical Analysis of Limestone, Lime and Hydrated Lime referred to in the report, with certain minor amendments (see Summary of the Proceedings, page 28) were accepted for publication as tentative and appear on pages 597–604.

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[1] See 1918 Book of A.S.T.M. Standards, p. 663.

REPORT OF COMMITTEE C-8

ON

REFRACTORIES.

Committee C-8 has held three general meetings during the year. The following recommendations submitted by the respective sub-committees have all been approved by the main committee and submitted to letter ballot vote. The results of this letter ballot are given in connection with each recommendation involving revisions, or the adoption of new tentative standards.

Sub-Committee I on Fusion Test.—This sub-committee has submitted a Test for Determination of Softening Point of Fire-Clay Brick which involves grinding the brick to powder and forming it into cones, of the same size and shape as the standard pyrometric (Orton) cones. These test cones are heated in a gas-fired furnace together with the standard pyrometric cones and the softening point is determined by reference to the deformation of the test cone and the standard cone.

The committee recommends that this test, which is appended to this report,[1] be accepted as a tentative standard. The result of the letter ballot vote of the committee on this recommendation is as follows: affirmative, 38; negative, 0; not voting, 4; total, 42.

Sub-Committee II on Analysis.—The committee recommends, in pursuance of the report of Sub-Committee II, that the present Tentative Methods for Ultimate Chemical Analysis of Refractory Materials (C 18–18 T) be continued as tentative.

Sub-Committee III on Industrial Survey.—This sub-committee has no report to offer at this time.

Sub-Committee IV on Thermal Conductivity and Expansion.—This sub-committee has no report to offer at this time.

Sub-Committee V on Porosity and Permanent Volume Change.—The committee recommends, in pursuance of the report of Sub-Committee V, that the present Tentative Test for Determination of Porosity and Permanent Volume Changes in Refractory Materials (C 20–18 T) be continued as tentative.

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[1] See pp. 594–596.—Ed.

Sub-Committee VI on Load Tests.—The committee recommends, in pursuance of the report of Sub-Committee VI, that the present Tentative Test for Refractory Materials under Load at High Temperatures (C 16–18 T) be continued as tentative.

Sub-Committee VII on Spalling Action.—This sub-committee has no report to offer at this time.

Sub-Committee VIII on Slagging Action.—This sub-committee has carefully investigated several points that have arisen in connection with the present Tentative Test for Slagging Action of Refractory Materials (C 17–17 T),[1] and has recommended that a molded ring cemented on the surface of the brick be used instead of the cored hole and that a standard synthetic slag be used instead of one of the several slags recommended. The use of the molded ring preserves the original surface of the grick, and the use of a standard slag makes the test of more general application. Several other minor changes in wording were made.

The committee accordingly recommends that the revised test, which is appended to this report,[2] be accepted as tentative to replace the present test. The result of the letter ballot vote of the committee on this recommendation is as follows: affirmative, 28; negative, 8; not voting, 6; total, 42.

Tentative Definitions.—A special sub-committee has considered the question of defining the resistance to heat and the constancy of volume of clay refractories for the purpose of classification. Heretofore there has been a very loose use of the terms high grade, medium grade, high duty, medium duty, etc., as adjectives in describing the relative resistances to heat of clay refractories. It was felt that a considerable advance would be made if some standard definitions could be evolved to give these terms definite meaning. The sub-committee has chosen as its criteria the change in volume of specimens when subjected to elevated temperature.

Proposed definitions are embodied in the appended Definitions of Clay Refractories, which the committee recommends be accepted as tentative. The result of the letter ballot vote of the committee on this recommendation is as follows: affirmative, 35; negative, 1; not voting, 6; total, 42.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part I, p. 578 (1918).

[2] See pp. 586–589.—ED.

This report has been submitted to letter ballot of the committee, which consists of 42 members, of whom 38 have voted affirmatively, none negatively, and 4 have refrained from voting.

Respectfully submitted on behalf of the committee,

A. V. BLEININGER,
Chairman.

W. H. FULWEILER,
Secretary.

EDITORIAL NOTE.

The proposed Tentative Test for Determination of Softening Point of Fire Clay Brick and the Tentative Definitions for Clay Refractories referred to in this report were accepted for publication as tentative and appear on pages 594–596 and 625–627.

The proposed revised Tentative Test for Slagging Action of Refractory Materials referred to in the report, with certain amendments (see Summary of the Proceedings, page 27) were accepted for publication as tentative and appear on pages 586–589.

REPORT OF COMMITTEE C-9
ON
CONCRETE AND CONCRETE AGGREGATES.

One formal meeting of Committee C-9 was held during the past year, in addition to an informal meeting called to review the status of the work and to discuss the best procedure for continuing it with renewed vigor.

The work of this committee has been greatly hampered by shortage of laboratory assistants and by the inability of many of the members to devote their time to committee matters because of activities incident to the war. It was decided early in the year that in view of the unsettled conditions the various sub-committees should work up data already accumulated, and to a considerable extent this has been done. Matters have progressed to such a state that it is expected during the coming year to reach definite conclusions on many of the fundamental principles of concrete manufacture and to present the results at the annual meeting in 1920.

Progress reports have been submitted by most of the sub-committees. Sub-Committee II on Laboratory Tests for Concrete and Laws of Mechanical Mixtures, Prof. Duff A. Abrams, chairman, is endeavoring to determine the laws of the size and grading and other properties of aggregates on the strength and properties of concrete, and to show how these laws might be applied to the practical phases of concrete making.

Sub-Committee III on Sampling and Testing of Field Concrete presented no report. Mr. Wm. M. Kinney has resigned from the chairmanship and is succeeded by Mr. Russell S. Greenman. This sub-committee has already presented Suggested Methods for Making and Testing Field Samples of Concrete.[1] The sub-committee has been instructed to continue its investigations by looking into the suitability of waterproofed pasteboard cartons for use as molds for field-molded specimens of concrete.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVII. Part I, p. 322 (1917).

Sub-Committee IV on Relative Value of Various Strength Tests, A. T. Goldbeck, chairman, presented a progress report giving the results of tests made at Massachusetts Institute of Technology, Ohio State University, University of Texas, University of Wisconsin, Iowa State University, Lewis Institute and the Bureau of Public Roads. The indications furnished by these tests are that tension, compression and transverse tests of mortar were practically equally concordant and that none of the mortar tests was alone sufficient for indicating the degree of suitability of a sand for use in concrete. These results at the present time are to be regarded as merely tentative.

Sub-Committee V on Impurities Affecting Fine Aggregates, F. W. Kelley, chairman, has been severely handicapped by frequent changes in personnel engaged on the chemical researches of this committee at Lewis Institute, Chicago. In connection with the Color Test for Impurities of Sand,[1] attempts have been made to obtain more satisfactory and more permanent color standards than the originally recommended tannic acid solutions. These solutions are not permanent in color and color glass or color cards have been suggested.

An elaborate investigation of the effect of organic impurities on the strength of concrete is being carried out at Lewis Institute, Chicago. These tests include mixtures of 1:7, 1:5, 1:4, 1:3 and 1:2, using different sizes and grading of aggregates. The tests will extend to the two-year period. Organic impurities in the form of admixtures will be added to these mixes.

In addition to the above investigation, a large mass of information is being accumulated at the Lewis Institute on samples of sand from all parts of the United States. Parallel tests on these samples are being made for organic impurities, mortar strengths and other properties.

Accelerators and retarders for cement are likewise being studied and will be useful in interpreting the results of other investigations now being made by this sub-committee.

Sub-Committee VI on Methods of Tests for Voids, Weights, Density, Specific Gravity and Consistency, Cloyd M. Chapman, chairman, has investigated nine different methods for determining the weight per cubic foot of fine aggregates and most of the results of these tests have been tabulated and plotted. Definite recommendations regarding a method for making a determination of the weight per cubic foot of fine aggregates are almost ready to be announced. The matter of the proper modifications of the Jackson Specific Gravity Apparatus to take care of light aggregates which fall outside the present scale of the instrument, is also being considered by this sub-committee.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVII, Part I, p. 327 (1917).

The work of Sub-Committee VII on Available Aggregates for Concrete, H. S. Mattimore, chairman, in tabulating the sources of aggregates in the United States has been interrupted, but will be continued by asking the cooperation of the national associations of producers of concrete materials. New materials for use as concrete aggregates, such as iron-ore tailings, graphite tailings, and garnet tailings, are being investigated.

This report has been submitted to letter ballot of the committee, which consists of 26 members, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

SANFORD E. THOMPSON,
Chairman.

A. T. GOLDBECK,
Secretary.

APPENDIX

TO

REPORT OF COMMITTEE C-9.

ABRAMS-HARDER FIELD TEST FOR ORGANIC IMPURITIES IN SANDS.[1]

The important characteristics of sand for use in concrete are durability, cleanness and grading. In the following discussion we are concerned only with the question of cleanness. Experience in concrete construction and numerous tests have shown that the appearance of a sand is not a safe criterion for determining its suitability for use in concrete. For example, a sand which appears dirty may be entirely free from organic impurities and give excellent results, provided the characteristics of durability and grading are satisfactory. On the other hand, many sands which appear to be clean are coated with organic impurities of a nature that will produce a very inferior concrete.

Numerous tests have been used for determining whether or not a sand possesses the requisite cleanness for use in concrete. The most common tests which have been used for this purpose are the determination of silt, and the loss in weight resulting from heating the sand to a red color (ignition test). The silt test gives a measure of the amount of fine material—generally clay or loam—which is contained in the sand, but furnishes no information as to the probable effect of such materials on the strength and durability of concrete or mortar made from the sand. Experimental work carried out in the Structural Materials Research Laboratory, Lewis Institute, Chicago, by Prof. Duff A. Abrams, in charge, and Dr. Oscar E. Harder, Chemist, has shown that it is the presence of organic impurities of a humus nature that is responsible for the effects observed from using sand of this kind. This humus material usually comes from the over-burden of soil found in most sand pits; it may find its way into the sand in other ways. It has been pointed out by many writers that the detrimental effect of silt in concrete is not proportional to the quantity of *silt* in the sand. The explanation for this result lies in the fact that it is only the impurities of an organic nature that have a decidedly injurious effect in retarding or preventing the setting and hardening of the cement; consequently, a considerable proportion of clay may be present without producing any effect other than a reduction in the strength which may be expected from the change in the grading of the aggregate.

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[1] For more complete discussion of this test, see Report of Committee C-9, *Proceedings*, Am. Soc. Test. Mats., Vol. XVII, Part I, pp. 327–333 (1917).

Researches carried out in the Structural Research Laboratory with the cooperation of Committee C-9 have shown that a simple colorimetric test may be used for detecting the presence of organic impurities of a humus nature in sands. (It is seldom that organic impurities other than of a humus nature are found in natural sand.)

Two methods of testing for organic impurities have been developed:

1. An approximate test for field use.
2. A more exact method for use in the laboratory.

The laboratory method differs from the field method principally in that comparison is made with a definite color standard. Only the field test will be presented here.[1]

METHOD FOR FIELD TEST.

The field test consists of shaking the sand thoroughly in a dilute solution of sodium hydroxide (NaOH) and observing the resultant color after the mixture has been allowed to stand for a few hours. Fill a 12-oz. graduated prescription bottle to the 4½-oz. mark with the sand to be tested. Add a 3-per-cent solution of sodium hydroxide until the volume of the sand and solution, after shaking, amounts to 7 oz. Shake thoroughly and let stand for 24 hours. Observe the color of the clear liquid above the sand. A good idea of the quality of the sand can be

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[1] For a discussion of the laboratory test, see "Colorimetric Test for Organic Impurities in Sands," by Duff A. Abrams and Oscar E. Harder, *Circular No. 1*, Structural Materials Research Laboratory.

PLATE V.
PROC. AM. SOC. TEST. MATS.
VOL. XIX, PART I.
REPORT OF COMMITTEE C-9:
ORGANIC IMPURITIES IN SANDS.

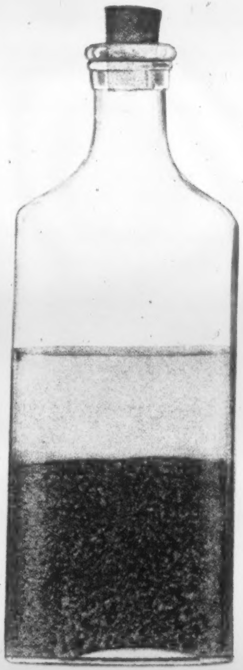

FIG. 1.

FIG. 2.

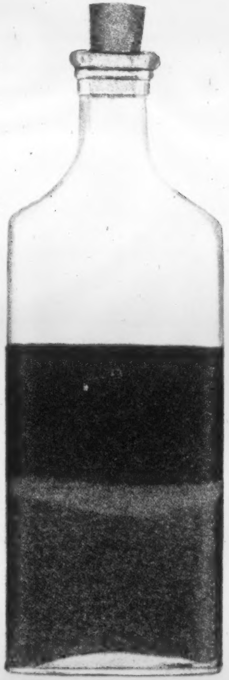

FIG. 3.

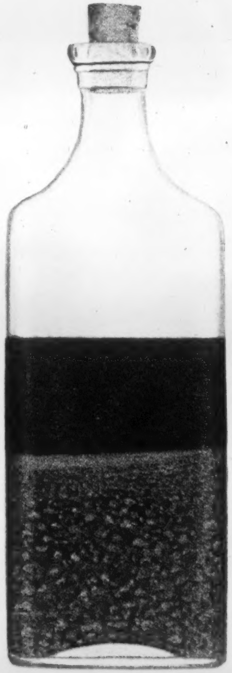

FIG. 4.

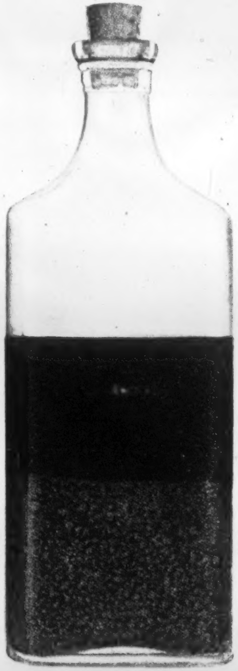

FIG. 5.

Sands suitable for use in high-grade concrete.

Sands which may be used in unimportant concrete work.

Sands which should never be used in concrete.

An unusually bad sand, soil or loam.

COLORS OF TREATED SANDS WITH SUGGESTED RANGES OF APPLICATION.

formed earlier than 24 hours, although this period is believed to give best results.

If the solution resulting from this treatment is colorless, or has a light yellowish color (Plate V, Fig. 1), the sand may be considered satisfactory in so far as organic impurities are concerned. On the other hand, if a dark colored solution of a color deeper than that indicated by Fig. 2 is produced, the sand should not be used in high-grade concrete such as that required in roads and pavements, or in building construction. Sands showing color as dark as that in Fig. 3 may be used in unimportant concrete work. Sands showing colors darker than that in Fig. 3 should never be used for concrete. Fig. 5 represents the color of the solution obtained with an unusually dirty sand or from a sample of soil high in loam. A small quantity of material of this kind would make a sand unsuitable for use in concrete.

Color Values.—While it is not practicable to give exact values for the reduction in strength corresponding to the different colors of solution, the tests made thus far show this relation to be about as follows:

COLOR NUMBER.	REDUCTION IN COMPRESSIVE STRENGTH OF 1 : 3 MORTAR AT 7 AND 28 DAYS, PER CENT.
Fig. 1	None
Fig. 2	10 – 20
Fig. 3	15 – 30
Fig. 4	25 – 50
Fig. 5	50 – 100

Washing dirty sands has the effect of greatly reducing the quantity of organic impurities. However, even after washing, sands should be examined in order to determine whether the organic impurities have been reduced to harmless proportions.

Apparatus.—The following list includes sufficient apparatus for making five field tests at a time:

5 12-oz. graduated prescription bottles;
Stock of 3-per-cent solution of sodium hydroxide (dissolve 1 oz. of sodium hydroxide in enough water to make 32 oz.).

This material can be purchased at most drug stores at a cost of about $1.00.

Conclusions.—Experience and tests have shown that it is the presence of organic impurities of a humus nature that is responsible for most defective sands. The colorimetric test furnishes a simple and inexpensive method of detecting the presence of such impurities. The test made in the manner described above will be found useful for:

1. Prospecting for sand supplies;
2. Checking the cleanness of sand received on the job;
3. Preliminary examination of sands in the laboratory.

This test is being used by a large number of testing laboratories, engineers and contractors in passing on the suitability of sands for use in concrete. In certain instances the test has been made the basis of specification requirement for sand.

Respectfully submitted on behalf of the committee,

SANFORD E. THOMPSON,
Chairman.

REPORT OF COMMITTEE C-11

ON

GYPSUM.

Committee C-11 has held two meetings during the past current year, one at Atlantic City, N. J., on June 28, 1918, and the other at Chicago, Ill., on March 20, 1919.

The unusual conditions brought about by the government's war activities has made it impossible to carry out any prearranged program of activities. Many committee members were engaged upon government war activities making it impossible for such members to attend meetings or give much time to sub-committee work.

For the reasons stated, it was not until the fall of 1918 that the sub-committees were able to continue work. The substance of this report indicates the work done by these sub-committees as follows:

Tentative Specifications for Gypsum and Calcined Gypsum.—These two specifications, prepared by Sub-Committee I on Gypsum for Various Uses, Mr. F. A. Wilder, chairman, cover gypsum for use as fertilizer, in the manufacture of Portland cement, and for wall plasters, structural products, potteries, etc.

They have been adopted by letter ballot vote of the committee as follows: Specifications for Gypsum: affirmative, 17; negative, 0; not voting, 12; Specifications for Calcined Gypsum: affirmative, 16; negative, 1; not voting, 12. The committee accordingly recommends that they be published as tentative standards of the Society.

Tentative Specifications for Gypsum Plasters.—These specifications have been prepared by Sub-Committee II on Gypsum Plasters, Mr. D. L. Haigh, chairman. They are divided into six parts, under the following headings:

Materials and standards.
Base or backgrounds.
Grounds.
Application.
General precautions.
Work and workmanship.

In the 1915 report of the committee, in which the program of work was outlined, the committee expressed the desirability and necessity of prescribing methods of application and erection as a part of specifications for gypsum. Committee C-11 then suggested that it be permitted to refer this question, as it affects the preparation of gypsum specifications, to the Executive Committee of the Society for consideration.

Accordingly, Committee C-11 submitted to the Executive Committee a copy of the specifications for Gypsum Plasters, including requirements for base materials and application. The Executive Committee at that time advised Committee C-11 as follows:

> "It was the sense of the meeting that inasmuch as this matter had been received too late for adequate analysis or for prior reference to authorities, the Secretary-Treasurer be authorized to inform the committee that they may feel free to present these proposed standard specifications at the approaching annual meeting of the Society, with the understanding that further steps will be governed by the discussion and action at the annual meeting."

Much difficulty has been experienced in the use of gypsum for wall and ceiling plasters, and for structural products and purposes because of improper mixing and application on the work. Gypsum differs from most of the structural materials which have been given consideration by the Society, in that it is very materially affected, and may entirely fail to perform its functions, if it is not prepared and applied in a correctly specified manner. For example, the alum used in certain cities in clarifying water may cause a gypsum plaster to be quick-setting and unfit for service unless properly prepared. Slight impurities contained in certain sands will delay or prevent the hardening of gypsum plasters or gypsum for any purpose, or will cause the gypsum to become very quick-setting. Improper spacing or application of wood lath, plaster board, and similar plastering base materials may cause the failure of the plaster.

Therefore, the committee is still of the opinion that the several sections included in these specifications referring to constituent materials, base and backgrounds, methods of application and workmanship should be included with the specifications.

The Tentative Specifications for Gypsum Plasters have been adopted by the following letter ballot vote of the committee: affirmative, 13; negative, 2; not voting, 14. The committee accordingly recommends that they be published among the tentative standards of the Society.[1]

Tentative Report on Design of Reinforced Gypsum Beams.—This report has been prepared by Sub-Committee III on Structural Gypsum Products, Mr. W. A. Slater, chairman, and covers the essentials necessary to the use of reinforced gypsum in structural design as follows:

General assumptions.
Notations adopted.
Equations for the computations of reinforced simple beams of rectangular and "T" sections.
Working stresses and constants.

For the reasons previously stated, when referring to the nature of specifications suggested by Sub-Committee II, it is evident that specifications for strength of gypsum used for structural purposes, without reference as to how the gypsum is to be used, could not be of any appreciable value. Reinforced gypsum has peculiarities which makes necessary special considerations for design.

Chairman Slater in a letter accompanying his report includes the following:

> "Since there is no other committee of which I know within whose province would fall the making of such recommendations, and for the reasons stated, I believe that Committee C-11 is justified in asking that this matter be considered as falling in the class of exceptions recognized by the Executive Committee in statement issued by them and published in the Regulations Governing Standing Committees, Section 14, which in part reads as follows:
>
> "'If, however, it should appear to a given committee that the consideration of such matters (matters of engineering design and construction) is, for special reasons, indispensable in specifications designed to cover the customary relations between the producers and consumers of a given product, then reference to such matter in proposed specifications for that product shall be permitted within the scope necessary for the particular purpose above stated.'"

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[1] See Editorial Note on p. 329.

This report on design of reinforced gypsum beams has been adopted by letter ballot vote of the committee as follows: affirmative, 11; negative, 4; not voting, 14. The committee accordingly recommends that the report be published in the Proceedings.

Tentative Methods for Tests of Gypsum and Gypsum Products.—These methods have been prepared by Sub-Committee IV on Testing Methods, Mr. W. E. Emley, chairman, and contain suggested methods for the determination of the following:

Determination of free water.
Fineness.
Chemical analysis.
Microscopic examination.
Precautions for physical tests.
Consistency.
Water carrying capacity.
Dry bulk.
Wet bulk (method to be determined).
Time of set (method to be determined).
Tensile strength.
Sand carrying capacity (method to be determined).

These methods have been adopted by letter ballot vote of the committee as follows: affirmative, 13; negative, 1; not voting, 15. The committee accordingly recommends that they be published among the tentative standards of the Society.

Tentative Definitions of Terms Used in the Gypsum Industry.—Owing to conditions brought about by war necessities, and also by reason of the resignation of Mr. S. G. Webb, chairman of this sub-committee, nothing has been done in addition to the work commenced by Mr. Webb and published as a tentative standard in Volume XVIII, Part I, of the Proceedings, page 592 (1918).

The functions and uses of gypsum are more or less similar to those of several other materials, and many of these similar materials and others are used in gypsum products. In preparing recommended nomenclature for terms used, it will be necessary to correlate the nomenclature which has been adopted by other committees. This has been done so far as possible and where consistent with the basis of argument adopted by Sub-Committee V.

At the meeting of Committee C-11 held on March 20, 1919, Mr. A. H. Apted was elected chairman of Sub-Committee V.

It is expected that during the coming year many additional definitions will be supplied and that a "nomenclature" of gypsum products and uses will be more nearly complete than at present. Active work and cooperation will be carried on with the following committees in order to prevent conflict of terms used:

Committee C- 1 on Cement.
" C- 2 on Reinforced Concrete.
" C- 4 on Clay and Cement Sewer Pipe.
" C- 5 on Fireproofing.
" C- 6 on Drain Tile.
" C- 7 on Lime.
" C- 9 on Concrete and Concrete Aggregates.
" C-10 on Hollow Building Tile.
" D- 1 on Preservative Coatings for Structural Materials.
" D- 4 on Road Materials.

This report has been submitted to letter ballot of the committee, which consists of 29 members, of whom 18 have voted affirmatively, 1 negatively, and 10 have refrained from voting.[1]

Respectfully submitted on behalf of the committee,

R. J. WIG,
Chairman.

V. G. MARANI,
Secretary.

EDITORIAL NOTE.

The proposed Tentative Specifications for Gypsum and for Calcined Gypsum, and the proposed Tentative Methods for Tests of Gypsum and Gypsum Products, referred to in this report, were accepted for publication as tentative and appear on pages 575–580 and 613–624.

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[1] The committee has 31 members, but two members could not vote. Member A. P. Mills died in the service of his country in France, and Member L. I. Neale served at the front.

The proposed Tentative Specifications for Gypsum Plasters referred to in the report were not accepted for publication as tentative as recommended by the committee, but were ordered printed in the Proceedings as a part of the report of the committee, under the title "Tentative Report on Gypsum Plasters"; and the Executive Committee of the Society was requested to decide the question of including in specifications for materials requirements covering such matters as application and workmanship, and recommended practice in general.

The Tentative Report on Design of Reinforced Gypsum Beams was accepted for publication in the Proceedings.

APPENDIX I.

TENTATIVE REPORT
ON
GYPSUM PLASTERS.

This report treats with the subject of Gypsum Plasters under the following headings:

(A) Materials and Standards;
(B) Base or Backgrounds;
(C) Grounds;
(D) Application;
(E) General Precautions.

The committee solicits criticisms of the report, which should be directed, preferably before January 1, 1920, to the Secretary of Committee C-11, Mr. V. G. Marani, 111 W. Monroe Street, Chicago, Ill.

A. MATERIALS AND STANDARDS.

Testing.

1. (*a*) All materials mentioned shall comply with the specifications contained herein.

(*b*) The tests for the various chemical and physical properties of the materials herein provided for shall be performed in accordance with the Tentative Methods for Tests of Gypsum and Gypsum Products (Serial Designation: C 26–19 T) of the American Society for Testing Materials.

I. READY-MIXED GYPSUM PLASTER.

Definition.

2. Ready-mixed gypsum plaster is a plastering material in which the predominating cementitious material is calcined

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Editorial Note.—This report was originally proposed as Tentative Specifications for Gypsum Plasters, but on vote of the annual meeting in June, 1919, it was accepted simply as a report on the subject; and the Executive Committee of the Society was requested to decide the question of including in specifications for materials requirements covering such matters as application and workmanship, and recommended practice in general.

gypsum, and which is mixed at the mill with all the constituent parts in their proper proportion. It requires only the addition of water to make it ready for use.

Composition.

3. (*a*) *Scratch or First Coat.*—Ready-mixed gypsum plaster shall contain not more than two-thirds by weight of sand. The remainder shall contain not less than 75 per cent of its weight of calcined gypsum. The other 25 per cent of this remainder may be hydrated lime, ground clay, retarder or fiber, but not Portland or other hydraulic cement.

(*b*) *Browning or Second Coat.*—Not more than 75 per cent by weight of the ready-mixed gypsum plaster shall be sand. The remainder shall contain not less than 75 per cent by weight of calcined gypsum. The other 25 per cent of this remainder may be hydrated lime, ground clay, retarder or fiber, but not Portland or other hydraulic cement.

Time of Setting.

4. (*a*) *Scratch or First Coat.*—This plaster shall set in not less than $1\frac{1}{2}$ nor more than 5 hours.

(*b*) *Browning or Second Coat.*—This plaster shall set in not less than 2 nor more than 6 hours.

Tensile Strength.

5. (*a*) *Scratch or First Coat.*—Briquettes made of this plaster shall have a tensile strength of not less than 50 lb. per sq. in.

(*b*) *Browning or Second Coat.*—Briquettes made of this plaster shall have a tensile strength of not less than 40 lb. per sq. in.

Packing and Marking.

6. The plaster shall be shipped in packages and shall be dry and free from lumps. Each package shall be plainly labeled with the net weight, and the name of the brand and of the manufacturer.

Inspection and Rejection.

7. The plaster may be rejected within 30 days of receipt of the shipment by the consignee if it fails to meet any of the foregoing requirements.

II. NEAT GYPSUM PLASTER.

Definition.

8. Neat gypsum plaster is a plastering material in which not less than 85 per cent of the cementitious material is calcined gypsum, mixed at the mill with other materials in their proper proportion.

Composition.

9. Neat gypsum plaster shall contain not less than 85 per

cent by weight of calcined gypsum. The remainder shall be hydrated lime, ground clay, asbestos, retarder or fiber. It shall contain no Portland or other hydraulic cement.

Tensile Strength. 10. Briquettes made of neat gypsum plaster shall have a tensile strength of not less than 100 lb. per sq. in.

Packing and Marking. 11. The plaster shall be shipped in packages and shall be dry and free from lumps. Each package shall be plainly labeled with the net weight, and the name of the brand and of the manufacturer.

Inspection and Rejection. 12. The plaster may be rejected within 30 days of receipt of the shipment by the consignee if it fails to meet any of the foregoing requirements.

III. GYPSUM WOOD-FIBER PLASTER.

Definition. 13. Gypsum wood-fiber plaster is a gypsum plaster in which fiber is used as the aggregate.

Composition. 14. Gypsum wood-fiber plaster shall contain not less than 80 per cent by weight of calcined gypsum and not less than 1 per cent of wood fiber made from a non-staining wood. The remainder shall be composed of hydrated lime, ground clay, asbestos, sand or retarder. It shall contain no Portland or other hydraulic cement.

Time of Setting. 15. Gypsum wood-fiber plaster shall set in not less than 1½ nor more than 6 hours.

Tensile Strength. 16. Briquettes made of gypsum wood-fiber plaster shall have a tensile strength of not less than 100 lb. per sq. in.

Packing and Marking. 17. The plaster shall be shipped in packages and shall be dry and free from lumps. Each package shall be plainly labeled with the net weight, and the name of the brand and of the manufacturer.

Inspection and Rejection. 18. The plaster may be rejected within 30 days of receipt of the shipment by the consignee if it fails to meet any of the foregoing requirements.

IV. CALCINED GYPSUM FOR WHITE OR GRAY FINISHING COAT.

Definition. 19. (*a*) Calcined gypsum is the product, made by mechanical process, resulting from the partial (incomplete) or complete dehydration of gypsum by means of heat.

(*b*) These specifications cover two grades of calcined gypsum, "White" and "Gray."

Fineness. 20. Calcined gypsum for white or gray finishing coat shall all pass through a 14-mesh sieve, and not less than 60 per cent shall pass through a 100-mesh sieve.

Time of Setting. 21. Calcined gypsum for white or gray finishing coat shall set in not less than 20 minutes nor more than 3 hours.

Tensile Strength. 22. Briquettes made of calcined gypsum for white or gray finishing coat shall have a tensile strength of not less than 200 lb. per sq. in.

Color. 23. Specifications for color to be determined by the Committee when the information is available.

Packing and Marking. 24. The plaster shall be shipped in packages and shall be dry and free from lumps. Each package shall be plainly labeled with the net weight and the name of the brand and of the manufacturer.

Inspection and Rejection. 25. The plaster may be rejected within 30 days of receipt of the shipment by the consignee if it fails to meet any of the foregoing requirements.

V. MOLDING PLASTER.

Requirements. 26. The requirements for molding plaster shall be as given in Specification IV for Calcined Gypsum for White or Gray Finishing Coat, Sections 19 to 25, with the following exception:

Time of Setting. 27. Molding plaster shall set in not less than 10 nor more than 40 minutes.

VI. CASTING PLASTER.

Requirements. 28. The requirements for casting plaster shall be as given in Specification IV for Calcined Gypsum for White or Gray Finishing Coat, Sections 19 to 25.

VII. FINISH COATS.

Trowel or Smooth Finish. 29. Material for trowel or smooth finish shall be composed of lime putty (Specification XI) and calcined gypsum, white or gray (Specification IV). The proportion of calcined gypsum and lime putty shall be varied according to the season of the year and the only practical method is to permit the experienced mechanic to use his judgment as to the proportion of each, according to the time of the year when the material is being applied, to make a proper finish. As a guide to the mechanic, 75 per cent by volume of lime putty and 25 per cent by volume of calcined gypsum is recommended.

Sand Float or Rough Finish. 30. Material for sand float or rough finish shall be composed of lime putty and calcined gypsum in the following proportions: Lime putty 1 part by volume; sand 3 parts by volume; these two materials are thoroughly mixed; before applying, mix 1 part by volume of calcined gypsum with not more than 9 parts of this mixture.

VIII. SAND.

Sand. 31. Sand for all plastering purposes shall be free from salt or alkali, and shall not contain more than 8 per cent by weight of loam or clay. It shall, when dry, pass through an 8-mesh sieve and not less than 90 per cent by weight shall be retained on a 48-mesh sieve.

IX. HAIR.

Hair. 32. The hair shall be selected, long, clean cattle or goat hair, washed and pickered.

X. FIBER.

Fiber. 33. The fiber shall be clean, of good strength, and about 2 in. in length.

XI. LIME.

Lime. 34. Hydrated or quicklime shall comply with the Standard Specifications for Hydrated Lime (Serial Designation: C 6–15) or for Quicklime (Serial Designation: C 5–15) of the American Society for Testing Materials.

(*a*) If hydrated lime is used, it shall be mixed with water at least 24 hours before using.

(*b*) If quicklime is used, it shall be thoroughly slaked and screened and shall be allowed to stand three weeks before using.

XII. WATER.

Water. 35. Water shall be fresh, pure and clean.

NOTE.—Trouble may occur from the presence of any excessive amount of mineral or vegetable substances.

B. BASE OR BACKGROUNDS.

XIII. WOOD LATH.

Wood Lath.

36. Studs, joists and furring shall be spaced not less than 16 in. on centers, and shall be of such dimensions as to make walls and ceilings rigid. All wood lath shall be sound, of uniform thickness, free from knots, sap or bark, and not over $1\frac{1}{2}$ in. wide.

XIV. INTERIOR, WIRE OR METAL LATH AND FURRING.

Metal Lath Protection.

37. All lath and furring of wire, or sheet metal expanded shall be painted or covered with protection pigment, or shall be galvanized.

Weight and Gage.

38. For ceilings the supports shall be spaced not to exceed 16 in. on centers. The metal lath shall be made from a sheet or wire of not less than No. 28 gage and shall weigh not less than 3.4 lb. per sq. yd. For wide walls, furring, and similar vertical lathing the supports shall be spaced not to exceed 16 in. center to center and the metal lath shall be made from a sheet or wire of not less than No. 28 gage and shall weigh not less than 2.5 lb. per sq. yd.

Where greater spacing of supports is necessary special types of ribbed lath, or special supporting construction, shall be provided.

XV. GYPSUM PLASTER BOARD.

Definition.

39. Gypsum plaster boards are used as a sheet lath or base for gypsum plaster on walls, ceilings and partitions on the interior of buildings.

Composition.

40. Gypsum plaster board shall consist of sheets or slabs composed of one or more layers of hydrated gypsum plaster, with or without fiber, reinforced on the surface with chip board, or felt.

Thickness.

41. The thickness of plaster boards shall average not less than the following:

(*a*) $\frac{3}{8}$ in. thick with permissible local variations of $\frac{1}{16}$ in. plus or minus, and the thickness at any point in the board shall not be less than $\frac{1}{4}$ in.;

(*b*) $\frac{5}{16}$ in. thick with permissible local variations of $\frac{1}{16}$ in.

plus or minus, and the thickness at any point in the board shall not be less than $\frac{3}{16}$ in.;

(*c*) $\frac{1}{4}$ in. thick with permissible local variations of $\frac{1}{16}$ in. plus or minus, and the thickness at any point in the board shall not be less than $\frac{3}{16}$ in.

Dimensions.

42. (*a*) The width shall be 32 in. with a permissible variation of $\frac{1}{4}$ in. less than the dimension specified, and the length shall be 24, 36, or 48 in. with a permissible variation of $\frac{1}{2}$ in. plus or minus.

(*b*) Unless otherwise specifically stated in the order, plaster boards of the widths specified and in lengths of 18 and 30 in. may be included in amount not exceeding 5 per cent of any single car load.

Weight.

43. The weight per thousand square feet of plaster board shall conform to the following:

(*a*) For $\frac{3}{8}$ in. thick, not less than 1500 nor more than 2000 lb.;

(*b*) For $\frac{5}{16}$ in. thick, not less than 1250 nor more than 1600 lb.;

(*c*) For $\frac{1}{4}$ in. thick, not less than 1200 nor more than 1500 lb.

Strength.

44. (*a*) Strength test samples shall be 12 in. wide and approximately 18 in. long, and when tested shall be supported on parallel knife edge bearings spaced 16 in. and loaded through a similar bearing midway between the supports.

(*b*) When tested as described, samples taken from the plaster boards shall carry not less than the following loads:

THICKNESS, IN.	LOAD, LB.	
	Stress Across Fiber of Surfacing.	Stress Parallel with Fiber of Surfacing.
$\frac{3}{8}$	40	20
$\frac{5}{16}$	[a]	[a]
$\frac{1}{4}$	[a]	[a]

The minimum acceptable strength shall be not less than 5 lb. below the averages given.

(*c*) Samples tested shall fail by rupture of the surfacing and core and not by the breaking of the bond between the surfacing and the core.

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[a] To be determined by the Committee when the information is available.

Cores. 45. The cores shall consist of the hydrated calcined gypsum plaster to which may be added not to exceed 15 per cent by weight of sawdust or other vegetable fiber intimately mixed. Cores shall be of sufficient thickness throughout to make the finished plaster boards conform to the specifications as to thickness of the finished product.

Surfacing Material. 46. The surfacing material shall be composed of plain chip board, felt or other stock of the same character, which shall be securely bonded to the core and shall completely cover the larger surfaces, with a permissible variation of $\frac{1}{4}$ in. at the edges along the shorter dimension.

Finished Product. 47. The surfaces shall be such that they will readily receive and retain gypsum plaster. The edges and ends shall be reasonably straight and solid. The corners shall be square with a permissible variation of $\frac{1}{4}$ in. in the full width of the boards. The boards shall be free from cracks and imperfections that will render such boards unfit for use.

NOTE.—Plaster boards will be considered acceptable that have their corners blurred or broken, provided that the broken portion is not more than $1\frac{1}{2}$ in. in length.

Packing and Marking. 48. Gypsum plaster boards shall be shipped so as to be kept dry and free from injury. Each board shall be plainly labeled with the name of the brand and of the manufacturer.

Inspection and Rejection. 49. Gypsum plaster boards shall conform to the foregoing requirements and shall be tested as provided for in Section 44 when determining their strength. Plaster boards may be rejected upon failure to conform to any of the foregoing requirements.

XVI. GYPSUM WALL BOARD.

Definition. 50. Gypsum wall boards are used without plaster coatings, as a finish on walls, ceilings and partitions on the interior of buildings.

Composition. 51. Gypsum wall board shall consist of sheets or slabs composed of a layer of hydrated gypsum plaster with or without fiber, and a surfacing of chip or manilla board on both sides.

Thickness. 52. The thickness shall average not less than $\frac{3}{8}$ in. with permissible local variations of $\frac{1}{32}$ in. plus or minus, and the thickness at any point in the board shall not be less than $\frac{5}{16}$ in.

Dimensions. 53. Where the wall boards are to be laid with joints butted, the width shall be 32, 36, or 48 in. with a permissible variation of $\frac{3}{32}$ in. plus or minus. Where the joints are to be filled with joint filler, the width shall be $31\frac{3}{4}$, $35\frac{3}{4}$ or $47\frac{3}{4}$ in. with a permissible variation of $\frac{3}{32}$ in. plus or minus. The length shall be 4, 5, 6, 7, 8, 9 or 10 ft., with a permissible variation of $\frac{3}{8}$ in. plus or minus.

Weight. 54. The weight shall be not less than 1500 nor more than 2000 lb. per thousand sq. ft. of wall board.

Strength. 55. (*a*) Strength test samples shall be 12 in. wide and approximately 18 in. long, and when tested shall be supported on parallel knife-edge bearings spaced 16 in. and loaded through a similar bearing midway between the supports.

(*b*) Such samples taken from the wall boards shall carry a load of not less than 80 lb. when the line of the supports is at right angles to the direction of the fiber of the surfacing, and not less than 32 lb. when the line of the supports is parallel to the fiber of the surfacing.

(*c*) Samples tested shall fail by rupture of the surfacing and core and not by the breaking of the bond between the surfacing and the core.

Cores. 56. The cores shall consist of hydrated calcined gypsum plaster to which may be added not to exceed 15 per cent by weight of sawdust or other vegetable fiber intimately mixed. Cores shall be of sufficient thickness throughout to make the finished wall boards conform to the specifications as to thickness of the finished product.

Surfacing Material. 57. The surfacing material shall be composed of plain chip, manilla, filled news, or other stock of the same general character containing sufficient sizing to meet the following conditions:

(*a*) Samples of the finished wall board shall sustain a static head of 1 in. of water (confined within a 2-in. ring on either of the surfaces of the board) for a period of not less than 2 hours without penetrating the surface sufficiently to stain the core.

(*b*) The surfacing material shall completely cover the two larger faces of the core and shall be securely bonded to it.

Finished Product. 58. The surface designed to be exposed on erection shall be true and free from imperfections that would render the wall boards unfit for use with or without decoration. The edges and ends shall be straight and solid. Where wall boards are to be butted the corners shall be square with both side edges. In cases where the joints are to be filled, the joints shall be square with both side edges with a permissible variation of $\frac{1}{8}$ in. in the full width of the boards. The finished product shall be dry and free from cracks and imperfections that would render such boards unfit for use.

Packing and Marking.

59. Gypsum wall boards shall be shipped so as to be kept dry and free from injury. Each board shall be plainly labeled with the name of the brand of the manufacturer.

Inspection and Rejection.

60. Gypsum wall boards shall conform to the foregoing requirements and shall be tested as provided for in Sections 55 and 57 when determining their strength and water permeation. Wall boards may be rejected upon failure to conform to any of the foregoing requirements.

XVII. GYPSUM PLASTER BLOCKS.

Plaster Blocks.

61. Gypsum plaster blocks when very dry shall be dampened to reduce suction, before the first coat of plaster is applied.

XVIII. TERRA-COTTA OR CLAY TILE.

Terra-cotta or Clay Tile.

62. Terra-cotta or clay tile shall be dampened to reduce suction, before the first coat of plaster is applied.

XIX. BRICK AND MASONRY.

Brick and Masonry.

63. Brick and masonry shall be dampened to reduce suction, before the first coat of plaster is applied. The interior surfaces of outside brick and masonry walls shall be furred or effectively damp-proofed before they are plastered.

XX. CONCRETE AND CEMENT SURFACES.

Concrete and Cement Surfaces.

64. All concrete and cement surfaces shall be cleaned free from efflorescence, dust, dirt or oil, and where smooth shall be well hacked before plaster is applied.

XXI. CORNER BEADS.

Corner Beads.

65. Corner beads shall be securely nailed in place before lathing, and shall be placed plumb, straight and flush with grounds.

C. GROUNDS.

XXII. METHOD OF SETTING GROUNDS.

Wood Lath. 66. For wood lath, the total nominal thickness including lath and plaster shall be $\frac{7}{8}$ in. for three-coat dry-scratch or set-scratch work, and $\frac{3}{4}$ in. for two-coat work.

Wire or Metal Lath. 67. For wire or metal lath, the total nominal thickness including lath and plaster shall be $\frac{7}{8}$ in. for three-coat dry-scratch or set-scratch work.

Gypsum Plaster Board. 68. For gypsum plaster boards, the total nominal thickness including boards and plaster shall be $\frac{7}{8}$ in. for three-coat dry-scratch or set-scratch work. In no case shall the thickness of the plaster on the surface of the boards be less than $\frac{1}{2}$ in.

Gypsum Plaster Blocks. 69. For gypsum plaster blocks, the grounds shall be set $\frac{5}{8}$ in. in thickness.

Brick. 70. For brick, terra-cotta and cement walls, the grounds shall be set $\frac{5}{8}$ in. in thickness.

D. APPLICATION.

XXIII. THREE-COAT WORK, DRY SCRATCH.

Three-coat Work Dry Scratch. 71. Three-coat work, dry-scratch plaster, when used on wood lath, wire or metal lath, brick, terra-cotta, masonry, gypsum plaster blocks, or plaster boards, shall be applied as specified below:

First Coat. 72. Apply first or scratch coat (with hair or fiber) well rubbed in, and scratch well with ordinary plasterer's scratcher and allow to become "bone dry" before applying second coat.

Second Coat. 73. Apply second or browning coat (with or without hair or fiber), using enough to fill out to the grounds and to make walls straight and plumb. Rod and darby to a rough surface, making angles and corners true, and allow to become "bone dry" before applying third or finishing coat.

NOTE.—The first or scratch coat may be used as a second or browning coat and this custom is generally followed, particularly in country work, as it avoids the necessity of shipping more than one material.

Third Coat. 74. (*a*) If trowel or smooth finish is to be used, apply trowel or smooth finish (Specifications VII and XXVIII) and trowel to a smooth hard finish, free from trowel or brush marks or other imperfections.

(*b*) If sand float or rough finish is to be used, apply sand float or rough finish and bring to an even granular sand-float finish, free from cat-faces or other imperfections.

NOTE.—For first-class work, minimizing cracking, staining and other imperfections, three-coat dry-scratch work gives the best results.

Only three-coat, dry-scratch work should be used on metal lath. It is not advisable to apply the second coat on metal lath until the first coat has become thoroughly dry.

XXIV. THREE-COAT WORK, SET SCRATCH.

Three-coat Work Set Scratch.

75. Three-coat work, set-scratch plaster, when used on wood lath, brick, terra-cotta, masonry, gypsum plaster blocks, or plaster boards, but not on the wire or metal lath, shall be applied as specified below:

First Coat.

76. Apply first or scratch coat (with hair or fiber) and follow as soon as this sets firmly with second coat.

Second Coat.

77. Apply second or browning coat (with or without hair or fiber), using enough to fill out to the grounds and to make walls straight and plumb. Rod and darby to a rough surface, making the angles and corners true, and allow to become thoroughly set for third or finishing coat.

Third Coat.

78. (*a*) If trowel or smooth finish is to be used, apply trowel or smooth finish (Specifications VII and XXVIII) and trowel to a smooth hard finish, free from trowel or brush marks or other imperfections.

(*b*) If sand float or rough finish is to be used, apply sand float or rough finish and bring to an even granular sand-float finish, free from cat-faces or other imperfections.

NOTE.—Three-coat set-scratch work is more liable to have cracks and show staining from wood lath, but in so far as strength is concerned it is equally as good as three-coat, dry-scratch work.

XXV. TWO-COAT WORK.

Two-coat Work.

79. Two-coat work, when used on wood lath, brick, terra-cotta, masonry, gypsum plaster blocks or plaster boards, but not on wire or metal lath, shall be applied as specified below:

First Coat.

80. Apply first or scratch coat (with hair or fiber), using enough to fill out to the grounds. Rod and darby to straighten,

and allow to become "bone dry" before applying second or finishing coat.

Second Coat. 81. (*a*) If trowel or smooth finish is to be used, apply trowel or smooth finish (Specifications VII and XXVIII) and trowel to a smooth hard finish, free from trowel or brush marks or other imperfections.

(*b*) If sand float or rough finish is to be used, apply sand float or rough finish and bring to an even granular sand-float finish, free from cat-faces or other imperfections.

XXVI. MOLDED WORK.

Molded Work. 82. (*a*) *Solid Cornices and Molding.*—All solid cornices and molding shall be blocked out with browning or second base coat of gypsum plaster to within $\frac{1}{4}$ in. of the finished surface and allowed to set for finishing coat. The finished moldings shall be composed of lime putty with calcined gypsum added at the building by the mechanic, in the proper proportion to secure a good working material and a satisfactory hard finish.

(*b*) *Furred and Lathed Cornices.*—To all furred and lathed cornices the scratch coat of gypsum plaster shall be applied and scratched, and allowed to set thoroughly. It shall then be blocked out with browning or second coat of gypsum plaster to within $\frac{1}{4}$ in. of the finished surface, and allowed to set for the finishing coat. The finished moldings shall be composed of lime putty with calcined gypsum added at the building by the mechanic, in the proper proportion to secure a good working material and a satisfactory hard finish.

NOTE.—In all run-work moldings applied over furred and lathed surfaces, the finished surface should be not less than 1 in. from the furring.

XXVII. ORNAMENTAL WORK.

Ornamental Work. 83. All ornamental plastering in the form of molded or case pieces of varying designs to be placed on cornices or moldings in place, shall be thoroughly keyed and securely fastened to the prepared surfaces of cornices or moldings. There are many acceptable methods employed to fasten or key the ornamental molded pieces to the surfaces, but special care should be exercised to secure a proper key in attaching solid moldings to the prepared surfaces.

XXVIII. FINISH COATS.

Finish Coats. 84. The finish coats shall be run to guide lines and made straight, level and plumb, with all arrises true and sharp.

85. (*a*) Trowel-finish coats shall be not over $\frac{1}{8}$ in. thick, and shall be troweled down true and smoothed with metal trowels and water brush to a polish free from defects and brush marks.

(*b*) Sand-float finish coat shall be floated true with cork float, to a sand finish free from defects.

XXIX. WOOD LATH.

Supports. 86. Studs, joists, rafters, furring and similar supports shall be spaced not to exceed 16 in. on centers.

Sitting. 87. Wood lath shall be spaced $\frac{3}{8}$ in. apart with four 3-penny fine wire nails to each lath, with ends $\frac{1}{4}$ in. apart on supports, with joints broken every seventh lath. All lath shall be put on horizontally. Under no circumstances shall laths stop or form a long straight vertical joint, nor shall any lath be put on vertically to finish out corners or angles or behind studding, from one room to another. Wood lath shall be thoroughly soaked and swelled at least four hours before the first coat of plaster is applied.

Grounds. 88. All grounds shall be nailed solid in angles before lathing. Should there be any furring not properly secured, the carpenter shall be notified to make the same permanent, before lathing is continued. Lath shall break joints above openings.

XXX. INTERIOR, WIRE OR METAL LATH AND FURRING.

Supports. 89. Studs, joists, rafters, furring and similar supports shall be spaced not to exceed 16 in. on centers. Where greater spacing of supports is necessary special types of ribbed lath, or special supporting construction, shall be provided.

Setting. 90. The metal lath shall be placed horizontally upon the supporting members, securing same with staples spaced not over 8 in. apart and driven home. Or, the supporting members may be furred out with $\frac{3}{16}$-in. round rods secured with staples spaced not to exceed 8 in., and the metal lath applied as hereinbefore stated.

Lapping and Wiring.

91. The metal lath sheets shall be lapped not less than $\frac{1}{2}$ in., or shall be interlocked on the sides and lapped not less than 2 in. end to end. All metal lath and furring shall be wired with tie wires not less than once between adjacent supports. Sheets shall be started not less than 4 in. from corners and shall be bent around the corners in such manner that no joints shall occur at any corner. Lath upon ceilings shall be bent down to extend not less than 4 in. upon all wall surfaces.

Staples and Tie Wires.

92. Staples used for securing metal lath or furring shall be not less than 1-in. No. 12 gage. Staples used for securing $\frac{3}{16}$-in. furring rods shall be not less than $1\frac{1}{2}$-in. No. 12 gage. All wiring used between supports shall be done with not less than No. 18 gage tie wire.

XXXI. GYPSUM PLASTER BOARD.

Supports.

93. Studs, joists, rafters, furring and similar supports shall be accurately spaced 12, 16 or 18 in. on centers, and shall be in proper alignment. The standard spacing of 16 in. is recommended.

Spacing.

94. All boards shall be spaced $\frac{1}{4}$ to $\frac{3}{8}$ in. apart on all sides.

Setting.

95. Lay boards parallel to the run of the supports. Horizontal joints on walls, and joints at right angles to ceiling joists, shall be broken at each board by starting each alternate tier with a half or a quarter sheet. On wood stud partitions, vertical joints shall not occur on the same studs on both sides of the partition.

Cutting.

96. To cut plaster board to suit requirements, score both sides and break against a straight edge. If sawing is preferred, provide firm platform, support board close to where cut is made, and saw.

Nailing.

97. Plaster boards shall be nailed directly to the supports. Nails shall be spaced not to exceed 6 in. on centers for walls and 4 in. on centers for ceilings. First nail entire middle of board, then follow by nailing all outer edges. No portion of any plaster board shall have less than a $\frac{3}{4}$-in. bearing upon the supports to which it is nailed.

Nails.

98. The nails used shall be $1\frac{1}{4}$-in. No. $11\frac{1}{2}$-gage wire nails with flat heads of not less than $\frac{3}{8}$-in.

Grounds.

99. Grounds shall be secured by nailing through the plaster

boards to the supporting members, and shall not be less than $\frac{7}{8}$-in. in nominal thickness. This thickness includes the thickness of the $\frac{3}{8}$-in. plaster board.

Precaution. 100. Do not sprinkle or wet gypsum plaster boards before the application of plaster.

XXXII. GYPSUM WALL BOARDS.

Supports. 101. Studs, joists, rafters, furring and similar supports shall be accurately spaced 12, 16, 18 or 24 in. on centers and shall be in proper alignment. The standard spacing of 16 in. is recommended.

Spacing. 102. Gypsum wall boards shall be closely butted at all joints and corners, or shall be spaced not less than $\frac{1}{4}$ in. where joint filler is to be used. In butt-joint work provision shall be made for boards to overlap the full thickness of the board at all internal and external angles.

Setting. 103. Lay boards parallel to the run of the supports. Provide headers for nailing at all ends of wall boards; every joint and edge shall be supported by a firm backing to nail to. Ceilings shall be covered first and all ceiling boards shall lap beyond the face of the wall boards the full thickness of the board.

Cutting. 104. To cut wall boards to suit requirements, score both sides and break against a straight edge. If sawing is preferred, provide firm platform, support board close to where cut is made, and saw from face side of the board always.

Nailing. 105. Wall boards shall be nailed directly to the supports. Nails shall be spaced not to exceed 3 in. at all edges and 9 in. elsewhere. Where joints are to be covered with battens the nailing may be spaced not to exceed 6 in. at all points. First nail entire middle of board, then follow by nailing all outer edges. Wall boards shall have a bearing of not less than $\frac{3}{4}$ in. upon all supports to which they are nailed. Nails securing the edges shall be driven $\frac{3}{8}$ in. from the edge of the board.

Nails. 106. The nails used shall be 3 penny, common or fine wire flat-head nails.

Grounds. 107. Grounds are not necessary. Headers or plates shall be placed between studs behind the wall boards in order to provide a backing and nailing surface to secure base boards, chair rails, moldings and similar interior finishes.

E. GENERAL PRECAUTIONS.

XXXIII. GENERAL PRECAUTIONS.

108. Precaution should be taken to see that all materials are mixed in clean, tight boxes, with clean, fresh water, and that all tools are kept clean. If a machine mixer is used it should be properly cleaned at frequent intervals. **Mixing Boxes and Tools.**

109. All material shall be applied before it has commenced to set. Re-tempered material shall not be used. **Mixing.**

In the use of neat material which requires sand to be added, the neat material and sand shall not be mixed and allowed to stand before the addition of the water.

110. The temperature of all buildings being plastered during cold weather shall be kept above freezing during the time of plastering. Extreme forced heat shall be avoided. **Heat.**

NOTE.—In cold weather it is always better to have all or part of the permanent heating system in operation before starting to plaster. Avoid the use of salamanders, coke pots or other temporary heating appliances or local drying, to keep the plastered surfaces free from coal-smoke stains.

111. While plastering, windows shall be in place, or other closures provided, as a protection against strong winds, and that ventilation may be controlled. Openings shall be kept sufficiently open to allow the escape of dampness. Drying and ventilation is governed by the time of year and weather conditions. **Drying and Ventilating.**

112. Gypsum plaster shall not be subjected to freezing temperature weather within 36 hours after application. If frost should get into any coat of plaster, the coat shall be free from frost and in good condition before application of the next coat. **Frost.**

APPENDIX II.

TENTATIVE REPORT

ON

DESIGN OF REINFORCED GYPSUM BEAMS.[1]

The following recommendations are intended to apply to the design of simple beams of reinforced gypsum.

It is assumed that:

1. The loads designed for are the weight of the structure and the static live loads.
2. The span length effective in causing moment is the distance between centers of supports.
3. Calculations will be made with reference to working stresses and safe loads for dry gypsum rather than with reference to ultimate strength and ultimate loads.
4. A plane section before bending remains plane after bending.
5. The modulus of elasticity of the gypsum is constant up to the ultimate load.
6. The ratio of the modulus of elasticity of steel to the modulus of elasticity of gypsum is 30.
7. In calculating the moment of resistance of beams the longitudinal tensile strength of the gypsum is neglected.
8. Initial stress in the reinforced gypsum due to the expansion or contraction of the gypsum is neglected. The cross-sectional area of gypsum effective in resisting the bearing pressure applied to it by the anchoring of the reinforcing bars is the projection of the anchor (either a hook or a plate) on a plane normal to the longitudinal axis of the beam.

It is recognized that the assumptions given are not entirely borne out by experimental data. They are given in the interest of simplicity and uniformity, and variations from exact conditions are taken into account in the selection of formulas and working stresses.

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[1] It is impossible within the scope of this report to give data on which the recommendations for design are based. The bibliography at the end of this report contains references to published literature supporting the report.

9. Reinforced gypsum as herein provided applies only to interior construction and to protected exterior construction.

10. Reinforced gypsum when used either in interior or protected exterior construction will be permitted to dry out as quickly as possible after hardening.

Tension and Compression.—The tensile stress in the reinforcement should not exceed 16,000 lb. per sq. in.[1]

The maximum compressive stress in a gypsum beam should not exceed 22 per cent of the ultimate compressive strength of the dry gypsum[2] to be used in the construction under consideration, when tested as a cylinder whose height is twice its diameter, and should not exceed 44 per cent of the ultimate strength of the gypsum when saturated[3] with water.

Modulus of Elasticity.—Results of tests indicate that the modulus of elasticity of dry gypsum is nearly constant up to the ultimate strength of the gypsum and that for saturated gypsum the stress-strain diagram approaches a parabola whose vertex is at the point representing the ultimate strength.

An approximate value of the modulus of elasticity for dry gypsum cast from a mixture of normal consistency is 1,000,000 lb. per sq. in.

Computations of stress in reinforced beams using such gypsum should be made on the basis of a ratio of $\frac{E_s}{E_g} = n = 30$ for dry gypsum. No recommendation is made for beams using a gypsum mixture of other than "normal consistency." (See Tentative Methods for Tests of Gypsum and Gypsum Products.)

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[1] This recommendation is the same as has been adopted by the Joint Committee on Concrete and Reinforced Concrete for tension in steel in reinforced-concrete beams. *Proceedings*, Am. Soc. Test. Mats., Vol. XVII, Part I, pp. 202 ff. (1917).

[2] The term "dry gypsum" is used here to mean hydrated gypsum from which all water, except that which is combined as water of crystallization, has been evaporated. Drying the specimen to constant weight in air having a temperature of 70° F. and a relative humidity of 50 per cent will produce "dry gypsum." Committee C-11 will later prepare a specification to which reference will be made.

[3] The term "wet" or "saturated," as herein used, refers to hydrated gypsum which after being dried (as specified) has been immersed in water to complete saturation but not longer than one hour. (See Tentative Methods for Tests of Gypsum and Gypsum Products (Serial Designation: C 26-19 T) of the American Society for Testing Materials.)

Bond Strength, Bearing Strength, and Diagonal Tensile Strength.—Bond strength, bearing strength against anchor hooks or plates, and diagonal tensile strength of reinforced gypsum beams are so closely interrelated that they are discussed under one head.

Any provision which helps to prevent slipping of the reinforcing bars increases so markedly the diagonal tensile strength of a beam that mechanical anchorage at the ends of reinforcing bars should be used in all cases except those in which the bond stress and the diagonal tensile stress to be resisted are very small.

It may be assumed as a basis for design that when effective mechanical anchorage is furnished, the bond stress actually developed at any point along the bar is one-half of that computed on the basis of pure beam action, and that the remainder of the resistance is furnished by the truss action developed by anchoring the bars.

Test results on beams with anchored bars indicate that at the maximum load only about one-half of the tension in the reinforcing bars is developed by bond and that the remainder is developed by the anchorage of the bars.

It is recommended that the allowable working bond stress as computed by Eqs. 9 and 9 (*a*), given in percentage of the compressive strength of the hydrated gypsum to be used in the construction, be not more than 1 per cent in case mechanical anchorage is not furnished, nor more than 5 per cent in case mechanical anchorage, conforming with the requirements hereinafter stated, is furnished.

Test results indicate that truss action in the beam due to anchorage of the bars comes into existence early in the test. They indicate also that there is little difference in the effectiveness per square inch of the bearing area of the anchorage whether the anchorage be furnished in the form of U-hooks at the ends of bars or in the form of bearing plates rigidly attached at their centers to the reinforcing bars. Assuming that the effectiveness is the same for the two cases the average bearing unit pressure may be considered a measure of the value of the anchorage.

It is recommended that the allowable average bearing pressure to be used in determining the value of anchorage be taken as 40 per cent of the compressive strength of the dry hydrated gypsum to be used in the construction under consideration, or 80 per cent of the wet hydrated gypsum, and that Eqs. 10 or 11 be used for computing the bearing stress.

Test results have indicated a marked increase in the shearing strength of beams in which bars have been bent up for web reinforcement, over the strength of similar beams having no bars bent up.

It is recommended that the allowable working stress in shear, given in percentage of compressive strength of the dry hydrated gypsum to be used in the construction under consideration, be not more than 1.5 per cent for beams with no bent up bars but with or without mechanical anchorage at the ends of the bars, and 4 per cent for beams which have mechanical anchorage conforming to the recommendations in this report and which have bars bent up in conformity with the recommendations hereinafter specified.

In order that the working stresses in shear above named may be used in design:

(*a*) The angle θ which the bent bar makes with the direction of the longitudinal axis of the beam should be not less than 18 nor more than 45 deg.;

(*b*) Except in cases of concentrated loading, one or more longitudinal reinforcing bars should be bent up at a section where the shearing unit stress is equal to or less than the allowable shearing stress for beams with no web reinforcement;

(*c*) In cases of concentrated loading where bending up of bars is necessary the distance between the load point and the first bend should not be greater than the depth of the beam, d;

(*d*) Proceeding from the point at which the first bar is bent up toward the end of the beam, other bars should be bent up at intervals not to exceed the distance e defined by Eq. 12;

(*e*) The distance from the last point of bending to the center of the support should be not greater than the distance e.

Between any section in the span and the section of zero shear the ratio of the total cross-sectional area of the bars bent up to the total cross-sectional area A_s should not exceed the value of $\frac{A_b}{A_s}$ given by Eq. 13 nor be less than the value given by Eq. 14.

One or more bars having a total cross-sectional area of not less than three-eighths of the total area, A_s, of the longitudinal reinforcement should extend throughout the length of the span in the bottom of the beam and these bars should have mechanical anchorage at their ends, except where the bond stress calculated by Eq. 9 is less than one per cent of the compressive strength of the gypsum.

The radius of bends except for U-hooks should be not less than $24a$.

The point of bending up is considered to be at the intersection of the axis of the inclined straight portion of the bar with the line parallel to the longitudinal axis of the beam and passing through the center of gravity of the longitudinal reinforcing area at the point of maximum moment.

NOTATION.

The notation and equations used in computations for reinforced gypsum beams are the same as those recommended by the Joint Committee on Concrete and Reinforced Concrete to apply to corresponding terms and operations.[1] Modifications, additions, and omissions have been made where the two reports do not cover the same ground, but an attempt has been made to avoid conflict in the use of terms.

Definitions of all symbols used in the equations referred to and sketches illustrating their application are here given.

(*a*) *Dimensions and Angles.*

d = depth of beam to center of steel;
b = width of beam; for T-beams, width of flange;
b' = width of stem of T-beam;
jd = arm of resisting couple;
kd = distance from compression surface to neutral axis;
x = distance from section of zero shear to any section of the beam;
i = distance from section of zero shear to center of reaction of beam;
e = maximum allowable distance between points of bending up bars;
a = diameter of reinforcing bar;

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[1] *Loc. cit.*

h = width of U-hook;

o = perimeter of reinforcing bar;

Σo = sum of perimeters of all reinforcing bars in beam;

θ = the angle which the bent-up straight portion of the reinforcing bar makes with the longitudinal axis of the beam.

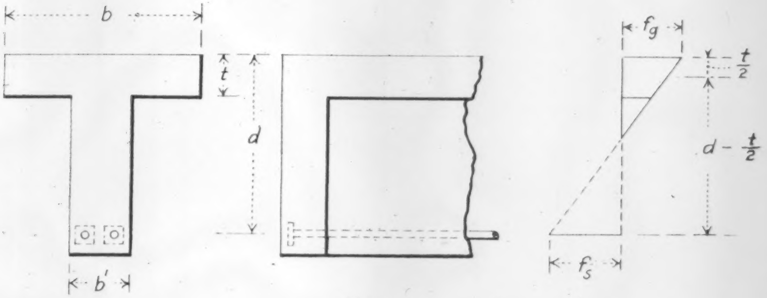

FIG. 1.

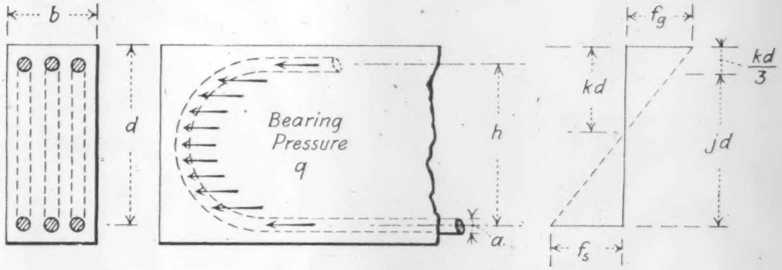

FIG. 2.

(*b*) *Areas.*

A_s = cross-sectional area of longitudinal reinforcement at point of maximum moment;

A_b = sum of cross-sectional area of bent-up bars between section of zero shear and any section at a distance x from the section of zero shear;

B = effective bearing area of anchor.

(*c*) *Moments, Stresses and Properties.*

M = bending moment or resisting moment;

f_s = tensile unit stress in steel;

f_g = compressive unit stress in gypsum;

f'_g = ultimate compressive unit strength of gypsum determined from 3 by 6-in. cylinders, or any other cylindrical test specimen whose height is twice its diameter;

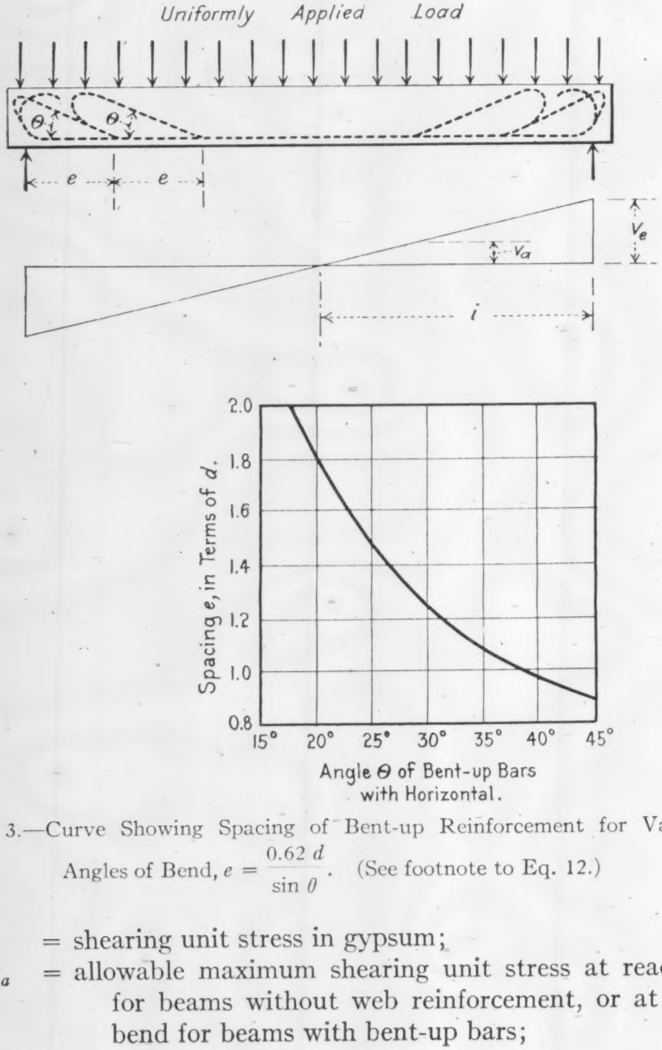

FIG. 3.—Curve Showing Spacing of Bent-up Reinforcement for Various Angles of Bend, $e = \frac{0.62\,d}{\sin\theta}$. (See footnote to Eq. 12.)

v = shearing unit stress in gypsum;

v_a = allowable maximum shearing unit stress at reaction for beams without web reinforcement, or at first bend for beams with bent-up bars;

v_e = shearing unit stress at reaction of beam having bent-up bars;
u = bond unit stress between gypsum and steel;
q = bearing unit stress between gypsum and anchor;
E_s = modulus of elasticity of steel;
E_g = modulus of elasticity of gypsum.

(*d*) *Ratios.*

k = ratio of depth of neutral axis to depth d of beam;
j = ratio of arm of resisting couple to depth d of beam;
$n = \frac{E_s}{E_g}$ ratio of modulus of elasticity of steel to that of gypsum;
p = steel ratio $= \frac{A_s}{bd}$.

SUMMARY OF EQUATIONS FOR COMPUTATIONS FOR REINFORCED GYPSUM UNIFORMLY LOADED, SIMPLE BEAMS.

Rectangular Beams.

$$f_s = \frac{M}{A_s jd} = \frac{M}{pjbd^2} \quad \text{.............(1)}$$

$$f_g = \frac{2pf_s}{k} = \frac{2M}{kjbd^2} \quad \text{.............(2)}$$

$$v = \frac{V}{bjd} \quad \text{.......................(3)}$$

$$k = \sqrt{2pn+(pn)^2} - pn \quad \text{.........(4)}$$

T-Beams.[1]

$$f_s = \frac{M}{A_s\left(d-\frac{t}{2}\right)} \quad \text{...............(5)}$$

$$f_g = \frac{M}{bt\left(d-\frac{t}{2}\right)}\,\frac{kd}{kd-\frac{t}{2}} \quad \text{.........(6)}$$

$$v = \frac{V}{b'\left(d-\frac{t}{2}\right)} \quad \text{.................(7)}$$

$$kd = \frac{2ndA_s+bt^2}{2nA_s+2bt} \quad \text{...............(8)}$$

Either Rectangular Beams or T-Beams.

$$u = \frac{V}{jd\Sigma o} \text{ (to be used when no anchorage is used)} \quad \text{...................(9)}$$

$$u' = \frac{1}{2}\,\frac{V}{jd\Sigma o} \text{ (to be used when anchorage conforming with requirements is furnished)} \quad \text{..........(9a)}$$

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[1] For all T-beams in which the neutral axis falls within the flange the equations will be the same as for rectangular beams except Eq. 7 for shear, in which for all T-beams the width b' of the stem should be used instead of the width b of the flange. Because of the low position of the neutral axis found with so high a value of n as 30 it will seldom be found that the neutral axis lies within the flange. For cases in which the value of p is less than 0.002 or in which t/d is 0.3 or more, the position of the neutral axis should be determined by means of the formula for rectangular beams. The substitution of $(d-t/2)$ for jd is an approximation giving errors of not more than about 2 per cent for the majority of cases. For more exact formulas for T-beams, reference is made to the Report of the Joint Committee on Concrete and Reinforced Concrete, *Proceedings*, Am. Soc. Test. Mats., Vol. XVII, Part I, p. 260 (1917).

$q = \frac{\pi a^2 f_s}{8B}$ (used when anchorage is furnished by means of plates rigidly attached at their center to the reinforcing bar) . . . . (10)

$q = \frac{\pi f_s}{8} \frac{a}{h}$ (used when anchorage is furnished by means of U-hooks on the ends of the reinforcing bars) . . . . (11)

$e = \left(\frac{2}{3 \tan\theta} + \frac{1}{2}\tan\theta - \frac{1}{6}\right) d$ . . . . (12)[2]

$\frac{A_b}{A_s} \overset{=}{<} \left(\frac{x}{i}\right)^2$ . . . . (13)

$\frac{A_b}{A_s} \overset{=}{>} 0.7\left(\left(\frac{x}{i}\right)^2 - \left(\frac{v_a}{v_e}\right)^2\right)$ . . . . (14)

SUMMARY OF PERMISSIBLE WORKING STRESSES AND CONSTANTS.

The working stresses are expressed in terms of the ultimate strength wet and of the ultimate strength dry. In all cases the lower of the two values should be used. Stresses and moduli are given in pounds per square inch.

f_s	16 000	
f_g	$0.22\ f'_g$	(dry specimen)
	$0.44\ f'_g$	(wet specimen)
v_a	$0.015\ f'_g$	(dry specimen)
	$0.030\ f'_g$	(wet specimen)
v_e	$0.040\ f'_g$	(dry specimen)
	$0.080\ f'_g$	(wet specimen)
u (for beams without anchorage)	$0.01\ f'_g$	(dry specimen)
	$0.02\ f'_g$	(wet specimen)
u' (for beams with anchorage)	$0.05\ f'_g$	(dry specimen)
	$0.10\ f'_g$	(wet specimen)
q	$0.40\ f'_g$	(dry specimen)
	$0.80\ f'_g$	(wet specimen)
E_s	30 000 000	
E_g (for dry hydrated gypsum from mixture of normal consistency)	1 000 000	
n (for dry hydrated gypsum)	30	

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[2] It has been found, upon further study, that Eq. 12 may be stated more simply as:

$$e = \frac{0.62\,d}{\sin\theta} \quad \text{(See Fig. 3.)}$$

The values of e as given by the two equations are approximately the same. However, the equation here proposed gives a slightly smaller maximum spacing than the first equation. The main advantage in the change is that of simplicity, and this advantage is considerable. With the second equation the distance between bent-up bars measured at right angles to their direction is held constant at $0.62d$.

EXPLANATION OF FIG. 4.

The upper curve of Fig. 4 (the graph of Eq. 13) is a parabola with its vertex at the lower left-hand corner of the diagram. Taking the bottom of the beam as drawn, as the zero line, the parabola may be used to represent a moment curve for the beam under uniform load. Therefore, the vertical distance from the bottom of the beam to the curve at any point will be proportional to the area of longitudinal reinforcement required at that point, and the vertical distance to the curve from the

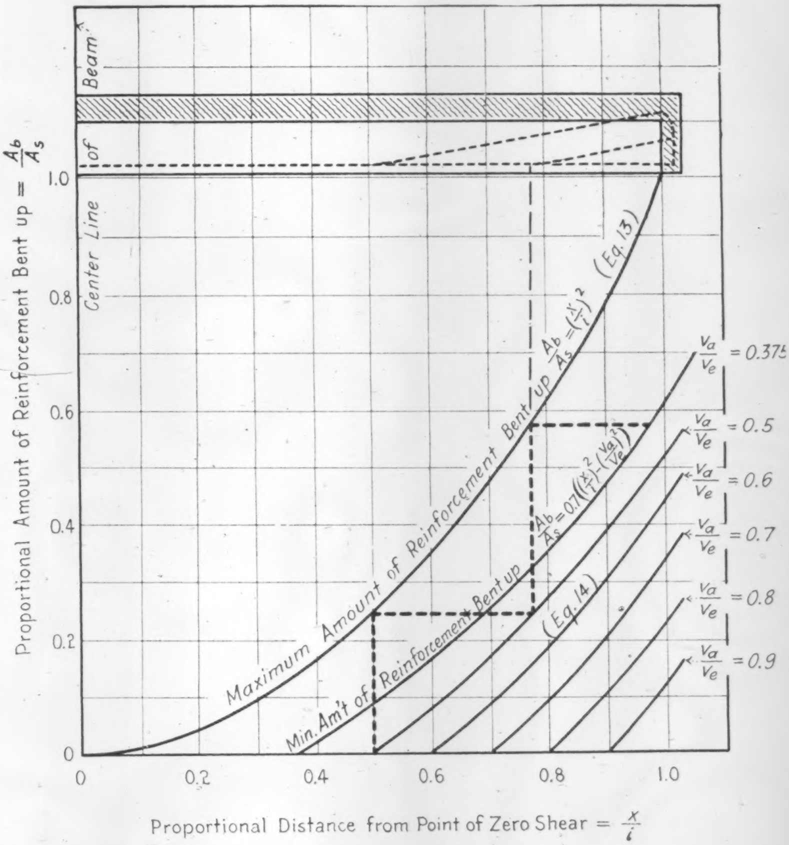

FIG. 4.—Curves Showing Maximum and Minimum Amounts of Bent-up Reinforcement. These Curves are Graphs of Eqs. 13 and 14, as Indicated.

horizontal line tangent to it at its vertex will be proportional to the total amount of reinforcement which may be bent up for web reinforcement between the center of the span (or the point of zero shear) and the point considered. Therefore this parabola represents the maximum amount of reinforcement which may be bent up.

The other curves on the sheet represent the minimum amount of reinforcement which must be bent up for different designs in which the end shear varies from the maximum allowable amount ($0.04 f'_g$) to the lowest for which web reinforcement is required ($0.015 f'_g$).

In any beam the first point at which web reinforcement will be required is the point at which the shearing unit stress is $0.015 f'_g$.

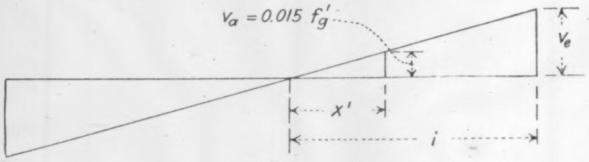

FIG. 5.

Letting x' be the distance from the point of zero shear to the first point of bending, it is apparent from Fig. 5 that

$$x' = \frac{v_a}{v_e} i = \frac{0.015 f'_g}{v_e} i.$$

Using various values of the end shear v_e, ranging from $0.04 f'_g$ down to $0.015 f'_g$, corresponding values of x' are found and through these points curves are drawn which represent the minimum amount of bent-up reinforcement required for these cases. These latter curves are graphs of Eq. 14 with different values of $\frac{v_a}{v_e}$ substituted.

Solution.—To illustrate the practical use of the diagram let it be required to design the web reinforcement of a beam 8 ft. long to carry a load of 228 lb. per lin. ft. (dead and live load), using gypsum whose ultimate strength is 1600 lb. per sq. in. The allowable end shear is $0.04 \times 1600 = 64$ lb. per sq. in.;

but if it be assumed that the minimum section for this span is as shown in Fig. 6, the end shear will be:

$$v_e = \frac{W/2}{b'(d-t/2)} = \frac{912}{262 \times 7.25} = 48 \text{ lb. per sq. in.}$$

$$v_a = 0.015 \times 1600 = 24 \text{ lb. per sq. in., and}$$

$$x' = \frac{v_a}{v_e}\, i = \frac{24}{48}\, i = 0.5\, i.$$

Therefore the first bar will be bent up midway between the center of the span and the support as shown by the stepped line in the diagram, and the intersection of the "riser" of the first step with the parabola shows that one-fourth of the longitudinal reinforcement may be bent up here. The intersection of the "tread" of the first step with the minimum curve shows that the next bend may be at a distance not greater than 0.76 i from the center of the beam. The riser of the second step shows that at this point the total amount of bent up reinforcement must be not greater than about $0.59A_s$. The horizontal line through this point passes above the minimum of the bent-up reinforcement required at the end of the beam and below the maximum allowed at this place, hence the amount of reinforcement bent up is satisfactory. This gives two bends, but if the "treads" of the steps shown were greater than the maximum spacing allowed by Eq. 12 it would be necessary to design the beam with a larger number of bars of smaller area so that bends might be made at closer intervals. Any arrangement of bends which falls between the limiting curves and provides not less than

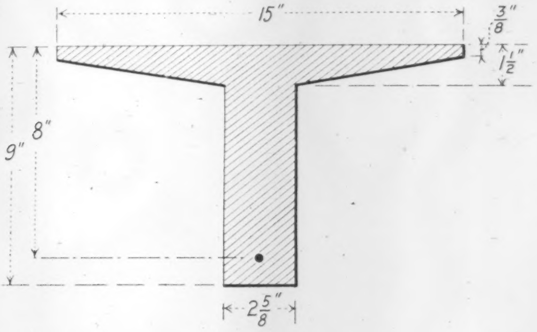

FIG. 6.

three-eighths of the total area as "through" bars is allowable.

The combination which employs one $\frac{1}{4}$-in. round, one $\frac{1}{4}$-in. square and one $\frac{5}{16}$-in. round nearly meets the conditions required as shown.

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Engineering and Cement World, Jan. 1, April 15, 1918.

The Iron Age, March 28, 1918.

The American Architect, April 17, 1918.

Proceedings, Western Society of Engineers, "Tests of Plain and Reinforced Specimens," by Slater and Anthes, Oct. 13, 1919.

Copies of the following official strength tests are in the files of the Gypsum Industries Association, and will be loaned upon request:

Willis A. Slater, Illinois University, 1915 to 1917.
James S. Macgregor, Columbia University, 1912, 1913, 1917.
R. H. Danforth, Case School of Applied Science, 1915, 1916, 1917.
M. O. Withey, University of Wisconsin, 1916.
R. W. Hunt & Co., St. Louis, Mo., 1917.

REPORT OF COMMITTEE D-1 ON PRESERVATIVE COATINGS FOR STRUCTURAL MATERIALS.

Committee D-1 on Preservative Coatings for Structural Materials which now has 97 members, has held two meetings since the last annual meeting of the Society. At the meeting held in Philadelphia on November 25, 1918, 40 members were present, and at the meeting held in Philadelphia on April 4, 1919, 32 members were present.

The committee recommends that the modification of the Tentative Test for Flash Point of Paint Thinners other than Turpentine (D 28–18 T)[1] proposed by Sub-Committee XI in its report appended hereto be made, that the title be changed to read "Test for Flash Point of Volatile Paint Thinners," and that as amended the method be submitted to letter ballot of the Society for adoption as standard.

A Sub-Committee on "Specifications for Paints for Railroads" has been organized.

Reports are appended from the following sub-committees:

Sub-Committee III on Testing of Paint Vehicles;
" " XI on Paint Thinners Other Than Turpentine;
" " XII on Turpentine;
" " XIV on Preparation of Iron and Steel Surfaces for Painting;
" " XVI on Terms Used in Reporting the Service Condition of Painted Surfaces.

This report has been submitted to letter ballot of the committee, which consists of 97 members; 55 ballots were cast,

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part I, p. 685 (1918).

42 not voting. The vote was taken on each section of the report. Following is the result of the ballot:

General Report..........................	51	affirmative;	none	negative.
Report of Sub-Committee III.............	47	“	“	“
Report of Sub-Committee XI.............	52	“	“	“
Report of Sub-Committee XII............	51	“	“	“
Report of Sub-Committee XIV............	42	“	“	“
Report of Sub-Committee XVI............	48	“	“	“

Respectfully submitted on behalf of the committee,

P. H. WALKER,
Chairman.

G. W. THOMPSON,
Secretary.

EDITORIAL NOTE.

The Tentative Test for Flash Point of Volatile Paint Thinners referred to in this report was approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1919, and appears in the Supplementary Pamphlet of A.S.T.M. Standards Adopted in 1919.

REPORT OF SUB-COMMITTEE III ON TESTING OF PAINT VEHICLES.

With the object of finding a shorter method than the Hübl method (18 hours) for the determination of the Iodine Number of Tung Oil, some work has been done by several members of the sub-committee on the Wijs method, but not enough to justify definite conclusions. This work will be continued.

Respectfully submitted on behalf of the sub-committee,

H. A. Gardner,
Chairman.

REPORT OF SUB-COMMITTEE XI ON PAINT THINNERS OTHER THAN TURPENTINE.

Standardization of Tag Closed Tester by the Bureau of Standards.—Sub-Committee XI established standard dimensions and allowable tolerances for the essential dimensions of the parts of the Tag Closed Tester and arranged with the manufacturer to prepare three special testers. One of these testers was accurately made to the prescribed standard dimensions. One departed the allowance maximum from the standard dimensions in the direction which would tend to raise the flash point, while the third tester departed from the standard dimensions in the direction which would tend to lower the flash point.

These three testers were submitted to the Bureau of Standards for examination and report.

As a result of their examination, the Bureau states their conclusions in the following words:

> "The tests of Table III indicate that the tolerances as given in Table I are permissible and that no difficulty should be experienced in keeping within the allowable variation in flash point of 1° C. in three tests. No tests have been made, however, in regard to the accuracy of the generally assumed correction for variation in barometer."

The report of the Bureau of Standards is given in full in the Appendix to this report.

The conclusion arrived at by the Bureau of Standards confirms the results of earlier investigations conducted by Sub-Committee XI and makes it reasonably sure that with testers constructed to the standard dimensions, results well within allowable variations may be secured.

After standardizing several testers, the Bureau of Standards suggested that a little greater tolerances might be allowed in some of the thermometer dimensions.

After further conference with the manufacturers, the following essential dimensions were agreed upon and are recommended by the sub-committee as standard:

ESSENTIAL DIMENSIONS OF TAG CLOSED TESTER.

DIMENSION.	NORMAL.	PERMISSIBLE VARIATIONS.
Depth of water surface below top of cup, in.	$1\frac{3}{32}$	$\pm\frac{1}{64}$
Depth of oil surface below top of cup, in.	$1\frac{5}{32}$	$\pm\frac{1}{64}$
Depth of top of bulb of oil thermometer when in place, belowtop of cup, in.	$1\frac{5}{16}$	$\pm\frac{1}{32}$
Inside diameter of oil cup at top, in.	$2\frac{1}{8}$	±0.005
Weight of oil cup, g.	68.	±1
Length of thermometer graduations, in.	$6\frac{1}{2}$	$\pm\frac{1}{2}$
Length of thermometer bulb, in.	$\frac{7}{16}$	$\pm\frac{1}{16}$
Diameter of thermometer, bulb, in.	$\frac{7}{32}$	$\pm\frac{1}{32}$
Diameter of bead on top of cover, in.	$\frac{5}{32}$	$\pm\frac{1}{64}$

The plane of underside of cover shall be between the top and bottom of the burner tip when fully depressed.

Thermometers shall be similar within above limits and accurate throughout their scale to within one-half of their smallest scale divisions.

The Bureau of Standards is now equipped with templates and gages for the standardization of these testers and certified testers can now be obtained from the manufacturers.

Centigrade vs. Fahrenheit Scale.—Although the sub-committee recommended last year the use of the Centigrade scale for thermometers, and used this scale in drafting the Tentative Test for Flash Point of Paint Thinners other than Turpentine (D 28–18 T),[1] it now seems advisable to include the Fahrenheit scale. The more general use of the Fahrenheit scale in the United States by the railroads, in the oil industry, in State and Municipal Laws, and in the recent specifications for petroleum products adopted by the United States Government for all Federal departments, makes it necessary, in the opinion of this sub-committee, to include this scale in its specifications for determining flash points.

Barometric Correction.—The general use of any correction factor for barometric pressure is considered by the sub-committee to be an unnecessary and undesirable refinement and it therefore recommends that such correction be made only in cases of dispute or when the barometric pressure differs more than $\frac{1}{2}$ in. from the standard presence of 29.92 in. (760 mm.).

The present Tentative Test for Flash Point states that a correction shall be made for barometric pressure by means of a table furnished with each instrument. This table was prepared from data published in Germany in 1910 and contained in Technical Paper No. 49 of the Bureau of Mines. It is based on a correction factor of 0°.35 C. for each 10 mm. of barometer difference. The factor, expressed in Fahrenheit degrees per inch, is also recommended by Redwood.[1]

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part I, p. 685 (1918).

The sub-committee therefore recommends that when corrections for barometric pressure are to be made these factors be used, instead of the table referred to.

Change of Title.—If Sub-Committee XII on Turpentine accepts the Flash Point method recommended by this sub-committee, then it is proposed that the title of this tentative standard method be changed to read, "Tentative Test for Flash Point of Volatile Paint Thinners."

Recommendations.—The sub-committee therefore recommends the adoption, as a standard by the Society, of the "Tentative Test for Flash Point of Paint Thinners other than Turpentine" which was presented last year,[2] with the necessary revisions as outlined above to adapt it to the Fahrenheit scale to include the standard essential dimensions, and to use Redwood's generally accepted factor for barometer correction, when such corrections are to be made, in place of the table referred to in the tentative test. The amended Tentative Test for Flash Point as recommended for adoption as standard is appended hereto.[3]

Future Work.—The sub-committee has recently appointed three special committees, one to draw specifications for petroleum distillates, one to draw specifications for coal tar distillates, and one on sulfur test. These subjects will have the attention of the sub-committees during the coming year.

Respectfully submitted on behalf of the sub-committee,

CLOYD M. CHAPMAN,
Chairman.

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[1] "A Treatise on Petroleum," Vol. II, p. 232, 1913.

[2] *Loc. cit.*

[3] This test is not reprinted here, but appears in the Supplementary Pamphlet of A.S.T.M. Standards Adopted in 1919.

APPENDIX.

REPORT OF U. S. BUREAU OF STANDARDS ON TAG CLOSED TESTERS.

In the Tentative Test for Flash Point of Paint Thinners other than Turpentine, presented to the American Society for Testing Materials, June, 1918, use is made of the Tag Closed Tester. It accordingly seemed desirable to standardize this instrument and to determine the relation between the variations in dimensions allowed in the construction of the instrument, and the resulting variations in flash point.

According to the data furnished by the sub-committee having the matter in charge, the permissible variations of essential dimensions are as given in Table I.

TABLE I.—PERMISSIBLE VARIATIONS IN DIMENSIONS OF TAG CLOSED TESTERS.

DIMENSION.	NORMAL.	PERMISSIBLE VARIATIONS.
1. Depth of water surface below top of cup, in.	$1\frac{3}{32}$	$\pm \frac{1}{64}$
2. Depth of oil surface below top of cup, in.	$1\frac{5}{32}$	$\pm \frac{1}{64}$
3. Weight of oil cup, g.	68	±1
4. Length of thermometer bulb, in.	$\frac{3}{8}$	$\pm \frac{1}{16}$
5. Diameter of thermometer bulb, in.	$\frac{3}{16}$	$\pm \frac{1}{32}$
6. Length of thermometer from top of bulb to underside of flange on ferrule, in.	$2\frac{3}{32}$	$\pm \frac{1}{32}$
7. Length of thermometer graduations —10° to +110° C., in.	$6\frac{1}{2}$	$\pm \frac{5}{16}$
8. Diameter of bead to which flame is adjusted, in.	$\frac{5}{32}$ to nearest $\frac{1}{64}$	
9. Inside diameter of oil cup, in.	$2\frac{1}{8}$	±.005
10. The plane of underside of cover should be between the top and bottom of the tip when fully depressed.		

At the suggestion of this Bureau, three instruments were selected, one to give the maximum reading of the flash point, one to give the minimum reading, and a third to be of normal dimensions. These three instruments were numbered respectively

131, 133, and 132. The dimensions of the thermometers were also made unequal for the same purpose.

Dimension 1 of Table I was found to be correct by means of gages furnished with the instruments, and gages for dimension 2 were used in filling the cups. Table II shows results of check of the other dimensions.

In instrument No. 131 the bottom of tip was in plane of underside of cover when fully depressed, in instrument No. 132 the center of tip, and in instrument No. 133 the top of tip was at this elevation.

By comparison of Table I and II, it is seen that the thermometer dimensions are within the allowable tolerances, except the length of bulb for thermometers Nos. 1,082,227 and 1,082,229, and dimension No. 6 for No. 1,082,229 and dimension No. 7 for thermometer No. 1,082,228.

TABLE II.

Instrument No....... Flash Point.......... Weight of Cup, g.....	131 Maximum 68.99		132 Normal 67.95		133 Minimum 67.00	
Thermometer No.....	1082221	1082228	1082225	1082226	1082227	1082229
Dimension No. 4, in..	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{9}{32}$	$\frac{9}{32}$
" " 5, in..	$\frac{13}{64}$	$\frac{3}{16}$	$\frac{13}{64}$	$\frac{3}{16}$	$\frac{5}{32}$	$\frac{5}{32}$
" " 6, in..	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{1}{8}$
" " 7, in..	$6\frac{3}{4}$	$6\frac{15}{16}$	$6\frac{15}{16}$	$6\frac{1}{4}$	$6\frac{1}{2}$	$6\frac{9}{16}$
" " 9, in..	2.125		2.123		2.126	

Table III shows results of flash point determinations made in strict accordance with the directions prepared by Sub-Committee XI of Committee D-1, of the American Society for Testing Materials.

The table mentioned in the directions for correcting flash points to the standard barometric pressure of 760 mm. was not available, and correction was made by subtracting 0°.35 C. for every 10 mm. difference in barometer. This is equivalent to 1°.6 F. for each inch of barometer as given by Boverton Redwood, in "A Treatise on Petroleum," Vol. 2, p. 232, 1913.

Tables in metric units, to aid in flash point correction, are given by Redwood, p. 242, and in Technical Paper No. 49 of the Bureau of Mines, p. 27, 1914. These tables could not, however, be used as they include only flash points from 19 to 35° C. at the standard barometer.

TABLE III.—FLASH POINT DETERMINATIONS.

Instrument No.	Depth of Oil Surface below Top of Cup, in.	Temperature of Water Bath at Start, deg. Cent.	Temperature of Oil at Start, deg. Cent.	Temperature of Oil at First Trial, deg. Cent.	Rate of Heating, deg. Cent. per min.	Barometer, mm.	Flash Point, deg. Cent.	
							Uncorrected.	Corrected to 760 mm. Barometer.
131	$1\frac{9}{64}$	24	24	30	1.0	748	36.0	35.6
		24	24	30	1.0	748	36.0	35.6
		25	25	30	1.0	748	36.0	35.6
	$1\frac{11}{64}$	25	25	30	1.0	748	36.0	35.6
		25	25	30	1.0	747	36.0	35.5
		25	25	30	1.0	747	36.0	35.5
132	$1\frac{9}{64}$	25	25	30	1.1	753	35.5	35.3
		25	25	30	1.0	753	35.5	35.3
		25	25	30	1.0	752	35.5	35.2
	$1\frac{11}{64}$	25	25	30	0.9	752	35.5	35.2
		25	25	30	1.0	751	35.5	35.2
		25	25	30	1.0	751	35.5	35.2
133	$1\frac{9}{64}$	25	25	30	1.0	748	35.0	34.6
		25	25	30	1.1	748	35.5	35.1
		25	25	30	1.0	748	35.5	35.1
	$1\frac{11}{64}$	25	25	30	1.0	747	35.0	34.5
		25	25	30	1.0	747	35.0	34.5
		25	25	30	1.0	747	35.0	34.5
131	$1\frac{9}{64}$	26	28	55	1.1	750	62.5	62.1
		27	28	55	1.5	750	62.5	62.1
		27	28	55	0.5	749	62.5	62.0
	$1\frac{11}{64}$	27	28	55	0.9	749	62.5	62.0
		23	23	55	1.5	753	62.5	62.3
		24	24	55	0.5	753	62.5	62.3
132	$1\frac{9}{64}$	27	28	55	1.0	748	62.0	61.6
		27	28	55	1.2	748	62.0	61.6
		27	28	55	0.6	748	62.0	61.6
	$1\frac{11}{64}$	27	28	55	1.0	750	62.0	61.6
		27	29	55	1.8	750	62.0	61.6
		27	29	55	0.5	750	62.0	61.6
133	$1\frac{9}{64}$	28	28	55	0.4	750	62.0	61.6
		28	28	55	1.8	750	62.0	61.6
		29	29	55	0.6	749	62.5	62.0
	$1\frac{11}{64}$	29	29	55	0.9	748	62.0	61.6
		29	29	55	1.8	748	62.0	61.6
		29	29	55	0.6	748	62.5	62.1

In the tests two oils were used, Nos. 1*S* and 150*D*, which were the same samples referred to in report of Sub-Committee XI for 1917.[1] The average flash point as found from tests in 13 laboratories was there given as 33°.3 C. from 35 tests for the former oil and 61°.2 C. from 37 tests for the latter.

As the Tag Closed Tester is intended primarily for low flashing oils, such as are used as paint thinners, for turpentine and such volatile explosive oils as come under the jurisdiction of the Underwriters' Laboratory, tests with oils of a flash point of about 35° C. or 100° F. are of most importance.

It will be seen that in spite of variations in instruments and in conditions of test as detailed in Table III, the maximum variation of flash point of the first oil was only 1°.2 C. in 18 tests, and 0°.7 C. for the second oil in the same number of tests.

Conclusion.—The tests of Table III indicate that the tolerances as given in Table I are permissible and that no difficulty should be experienced in keeping within the allowable variation in flash point of 1°.C. in three tests. No tests have been made, however, in regard to the accuracy of the generally assumed correction for variation in barometer.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVII, Part I, p. 448 (1917)

REPORT OF SUB-COMMITTEE XII ON TURPENTINE.

Sub-Committee XII submits herewith its report on the determination of the flash point of turpentine with the "Tag" Closed Tester, using the method developed by Sub-Committee XI for Paint Thinners other than Turpentine.

For this work four samples of turpentine were collected at the stills by agents of the Bureau of Chemistry. Sample No. 1 was pure gum turpentine, first year chipping, and from the first of the distillation. Sample No. 2 was pure gum turpentine, yearling, from the last of the distillation. Sample No. 3 was pure gum turpentine from old high boxes and from the last of the distillation. Sample No. 4 was pure steam-distilled wood turpentine.

The directions for conducting the tests were those given by Sub-Committee XI in conducting the investigation of the test in that sub-committee, and agree with the proposed test appended to the report of that sub-committee for the present meeting.

The individual results of the work are given in Table I.

It will be seen that the maximum difference in duplicate tests is 1°.5 C., which was obtained in the laboratory of the Bureau of Chemistry on sample No. 2 and was due to a slow application of the flame. The result, however, is not omitted, but is included as a matter of information. Results from the individual laboratories are excellent. In only three cases do duplicates differ by more than 0°.5.

The maximum variations between the averages from the different laboratories are: for No. 1, 1°.7 C.; for No. 2, 1°.35 C.; for No. 3, 2°.45 C.; for No. 4, 2°.45 C. Omitting the results from one laboratory the maximum variations between the averages from the different laboratories are: for No. 1, 1°.0 C.; for for No. 2, 0°.6 C.; for No. 3, 0°.45 C.; for No. 4, 0°.45 C.

It seems clear that the differences between the average figures for the several laboratories are due chiefly to difference in the speed of applying the test flame, a rather slow application

TABLE I.—FLASH POINT TESTS OF TURPENTINE WITH TAG CLOSED TESTER.

Laboratory.	Room Temperature, deg. Cent.	Barometer, mm.	Relative Humidity.	Temperatures, deg. Cent.			Time, hr. and min.		Flash Point, deg. Cent.	Remarks.
				Water Bath at Start.	Sample at Start.	Sample, First Test.	First Test.	Flash.		
SAMPLE No. 1										
Westinghouse-Church-Kerr Co. (C. MChapman)	19.5	761.7	55	22.0	19.5	28.0	10.39½	10.43½	32.5	
				20.5	19.0	27.5	12.23½	12.27	32.0	
				23.0	21.5	27.0	1.19½	1.24	32.5	
				23.5	21.5	27.5	2.18½	2.23½	32.5	
				25.5	23.0	27.5	3.10½	3.15	32.5	Average 32.5
Bur. Stand'ds (S. S. Voorhees)	22.8	753.4	38	21.0	22.0	28.0	10.35	10.39	32.0	
				21.0	21.5	27.0	11.03	11 08	32.0	Average 32.0
Inst. Industrial Research. (H. A. Gardner)	25.0	......		26.0	25.0	26.0	5.22	5.30	33.5	Bu. Chem. Tester
				22.0	23.0	28.0	5.48	5.55	34.0	
				25.0	25.0	28.0	6.10	6.17	33.5	Average 33.7
Bur. of Chem. (F. P. Veitch)				24.0	24.5	28.0	11.13	11.17	32.5	
				23.5	25.0	25.5	11.40	11.48½	33.0	
	26.0	755.5		24.0	24.0	28.0	12.07½	12.13	33.0	
				22.0	22.0	27.5	12.34	12.39	33.0	
	24.0	760.5	24	23.0	23.5	27.0	1.54	2.01½	33.0	Average 33.0
SAMPLE No. 2.										
Westinghouse-Church-Kerr Co.	19.5	761.7	55	22.0	19.5	27.5	11.06½	11.13½	35.0	
				25.0	21.5	30.0	12.37	12.40½	34.5	
				25.5	22.5	29.5	1.33	1.37	34.0	
				25.5	22.5	29.5	2.32½	2.36	34.0	
				25.5	22.5	29.0	3.23½	3.28	34.5	Average 34.4
Bureau of Standards	22.8	753.4	38	23.0	23.0	30.0	3.05	3.09	34.5	
				21.0	22.0	30.0	3.32	3.35½	34.0	
				18.0	20.0	30.0	4.03	4.07½	34.5	
				18.0	19.0	30.0	4.24½	4.28½	34.5	Average 34.5
Inst. Industrial Research	25.0	......		26.0	26.0	26.0	5.32	5.43	36.0	
				28.0	28.0	30.0	6.20	6.27	35.5	Average 35.75
Bureau of Chemistry	27.0	753.5		18.0	20.0	27.0	1.35	1.44	35.5	
				20.0	20.0	27.5	2.01½	2.07½	35.0	
				21.0	24.0	30.0	2.28	2.32	34.0	Slow flame, disregard
				24.0	25.0	30.0	2.45½	2.50½	35.0	
				23.0	24.0	30.0	3.08½	3.13	35.0	Average 35.0
SAMPLE No. 3.										
Westinghouse-Church-Kerr Co.	19.5	761.7	55	22.5	20.0	29.5	11.26½	11.31	35.0	
				24.5	22.0	30.0	12.51	12.55	35.0	
				23.5	21.5	30.0	1.48½	1.53½	35.0	
				26.0	23.0	30.0	2.45	2.49½	34.5	
				24.5	22.5	29.5	3.37½	3.42½	34.5	Average 34.8
Bureau of Standards	23.3	757.0	46	16.0	20.0	30.0	10.23	10.27½	35.0	
				16.0	21.0	30.0	10.45	10.50	35.0	Average 35.0
Inst. Industrial Research	25.0	......		25.0	25.0	28.0	5.12	5.22	37.5	
				27.0	27.0	not recorded	5.28	5.38	37.0	Average 37.25
Bureau of Chemistry	24.0	761.0	23	22.0	23.0	29.0	10.33	10.40½	35.5	
				25.0	25.0	30.0	10.54	10.59½	35.5	
				26.0	25.5	30.0	11.16	11.21	35.0	
				25.0	25.0	30.5	11.31	11.38	35.0	Average 35.25

TABLE I.—*Continued.*

Laboratory.	Room Temperature, deg. Cent.	Barometer, mm.	Relative Humidity.	Temperatures, deg. Cent.			Time, hr. and min.		Flash Point, deg. Cent.	Remarks.
				Water Bath at Start.	Sample at Start.	Sample, First Test.	First Test.	Flash.		
				SAMPLE No. 4.						
Westinghouse-Church-Kerr Co.	19.5	761.75	55	21.5	20.0	27.5	11.42½	11.48½	34.5	
				24.0	21.5	29.5	1.05½	1.10½	35.0	
				23.5	21.5	30.0	2.04½	2.09	34.5	
				26.0	23.0	29.5	2.57½	3.03½	35.0	
				24.0	22.0	30.0	3.52	3.57	35.0	Average 34.8
Bureau of Standards	23.3	757.0	46	16.0	16.0	28.5	11.06	11.12½	35.5	
				18.0	21.5	30.0	11.28½	11.33½	35.5	Average 35.5
Inst. Industrial Research	25.0			27.0	27.0	27.0	6.00	6.09	35.5	
				26.0	26.0	27.0	6.20	6.29	36.0	Average 35.75
Bureau of Chemistry	24.0	761.0	23	27.0	27.0	30.0	12.38	12.42½	35.0	
				23.0	24.5	30.5	12.57	1.01	35.0	
				25.0	25.0	29.5	1.14	1.21½	35.5	
				26.0	25.0	30.0	1.36½	1.43½	35.5	Average 35.25

Sample No. 1.—Authentic Pure Gum Spirits of Turpentine, Virgin, First of Run.
Sample No. 2.—Authentic Pure Gum Spirits of Turpentine, Yearling, Last of Run.
Sample No. 3.—Authentic Pure Gum Spirits of Turpentine, High Box (Third Year or Later), Last of Run.
Sample No. 4.—Authentic Pure Steam Distilled Wood Turpentine.

of the flame giving low flash points, and a rapid application giving high flash points.

The sub-committee, therefore, unanimously recommends that the "Tag" Closed Tester and the method of procedure outlined by Sub-Committee XI for the determination of the flash point of paint thinners other than turpentine, be adopted as standard for the determination of the flash point of turpentine.

Respectfully submitted on behalf of the sub-committee,

F. P. VEITCH,
Chairman.

REPORT OF SUB-COMMITTEE XIV ON THE PREPARATION OF IRON AND STEEL SURFACES FOR PAINTING.

Sub-Committee XIV submits the following progress report:

A meeting of the sub-committee was called for inspection of the test panels at Altoona, Pa., on Feb. 27, 1919, and at Brooklyn, N. Y., on the following day. Messrs. McDonnell, Sabin and Carpenter met and examined the test panels at Altoona and on the following day met Mr. Cheesman at Brooklyn and examined the test panels there.

At each location the panels were removed from the exposure frames a few days prior to the examination and were returned to the test frames on March 1, 1919.

The general condition of the panels at Altoona, with the exception of panel No. 10, was practically the same as that observed at the inspection on Feb. 14, 1918. The panels at Brooklyn were in generally good condition, with the exception of No. 10, but those of Series A, "Tests on New Steel," were not so good as at last year's inspection, nor so good as the panels at Altoona.

The deterioration of panels No. 10, schedule A-7, has materially progressed as is shown by photographs attached. A photograph of panel No. 1 at Brooklyn is also shown for the purpose of comparison. Spots on these panels where the coating was cut and surfaces scraped in the examination were covered with varnish (panel No. 10, Altoona) or paint (panels at Brooklyn).

The detailed record of inspection of the panels is shown on the tabulated statement attached, arranged in the same way as the similar statement in the 1918 report.

The sub-committee is of the opinion that a further exposure of one or two years will be required before conclusions can be properly derived from the tests, except as indicated in the case of panels No. 10. The corrosion on these panels is so marked in comparison with the other panels as to lead the sub-committee to conclude that the surface treatment accorded these panels is not to be recommended.

Respectfully submitted on behalf of the sub-committee,

A. W. CARPENTER,
Chairman.

APPENDIX.

REPORT OF INSPECTION OF TEST PANELS, FEBRUARY, 1919.

SERIES A.—TESTS ON NEW STEEL.

TEST No.	DESCRIPTION.	CONTITION AT ALTOONA ON FEB. 27, 1919.	CONDITION AT BROOKLYN ON FEB. 28, 1919.
1	Plates painted as received from mill; surfaces clean and free from rust, mill scale intact. Paint applied in warm, dry room.	No appreciable change from 1918 inspection.	Several breaks in coating in areas 4 to 5 in. from each end of panel, all obviously due to mechanical injury. Otherwise plate and film O.K. except a few pin-head rust spots, several in a straight line, over an area within 2 in. from the left side and a very few rust spots within 6 in. of the left side.
2	Test surface rather badly abraded, about 25 per cent of mill scale gone, slightly rusted, also smeared with tallow. Washed with benzine, scraped and wire-brushed. Painted in warm room.	No appreciable change from 1918 inspection.	Numerous rust spots (pin-head and larger) within 5½ in. of the top and within 4 in. of the bottom of the panel. A number of similar rust spots scattered through center of plate, a few on left edge and a very few on right edge.
3	Surface sand-blasted and painted immediately thereafter in warm, dry room.	No appreciable change from 1918 inspection.	Rust spots on ends, somewhat more than on No. 2. Scattered rust spots (pin-head size) over interior of surfaces, about the same as No. 2.

SERIES A—(*Continued*).

TEST No.	DESCRIPTION.	CONDITION AT ALTOONA ON FEB. 27, 1919.	CONDITION AT BROOKLYN ON FEB. 28, 1919.
4	Surfaces sand-blasted and heated immediately thereafter in an oven to 225° F. Painted while still warm.	No appreciable change from 1918 inspection. The granular points referred to in 1918 report have not changed appreciably.	Practically same as No. 3.
5	Surfaces sand-blasted and placed in cool damp room for 40 min. and painted therein. Temperature when painted 43–44° F.	No appreciable change from 1918 inspection.	Numerous breaks in coating 10 in. from top and especially in upper right corner. Otherwise about same as No. 4.
6	Plates as received from mill; sand-blasted and placed out of doors and painted there. Temperature 25–27° F. Both coats dried outside.	No appreciable change from 1918 inspection.	Rusted along abraded lines 3 in. from top and bottom, apparently due to clamps. 1¼ in. rust spot 1 in. from left side, 12 in. from top. Another ¾ in. from right side and 13 in. from top. Otherwise practically O.K. Generally equal to or better than No. 1.
7	Sand-blasted and exposed out of doors for 7 days during which some rust developed which was not removed before painting. Painted in warm, dry room.	No appreciable change from 1918 inspection.	Numerous rust spots within 3 in. of each end; otherwise only a very few scattered pinhead breaks. General condition between 3 in. lines about the same as No. 1.
8	Pickled, rinsed in hot water, neutralized with alkali solution and again washed. Painted in warm, dry room.	No appreciable change from 1918 inspection.	Slightly inferior to No. 1 but with same general characteristics.

SERIES A—(*Continued*).

TEST No.	DESCRIPTION.	CONDITION AT ALTOONA ON FEB. 27, 1919.	CONDITION AT BROOKLYN ON FEB. 28, 1919.
9	Pickled as for No. 8 and exposed to weather for 7 days. Some rust developed which was not removed before painting. Painted in warm, dry room.	No appreciable change from 1918 inspection.	Slightly inferior to No. 1; not quite so good as No. 8; same general characteristics.
10	As received from mill, were exposed to weather from Aug. 4, 1916, to Jan. 16, 1917, became deeply rusted, especially along diagonal bands. Some mill scale remained between diagonal bands. Surface cleaned with scraper and wire brush. Painted in warm, dry room.	Rust appears to be going on under such mill-scale as was (probably) beginning to rust underneath before painting; these areas appear raised; but perfectly smooth mill-scale seems to be good. There is a little rust, generally where all the scale was removed and some rust right near the edge of adherent mill-scale. At numerous points on this panel distinct rust spots are broken through the paint and there are a very few blisters of some size.	Conditions similar to that of Altoona panel, except in degree of corrosion which is much worse in this one.
11	Pickled and cleaned with cold water under pressure. Painted in warm, dry room.	No appreciable change from 1918 inspection.	Numerous rust spots scattered over whole surface—no particular concentration at ends except at lower right edge. Inferior to all preceding panels, except No. 10.

SERIES A—(*Continued*).

TEST No.	DESCRIPTION.	CONDITION AT ALTOONA ON FEB. 27, 1919.	CONDITION AT BROOKLYN ON FEB. 28, 1919.
16	Incompletely sand-blasted. Painted in warm, dry room.	No appreciable change from 1918 inspection.	Some breaks within clamp limits on lower end and very few at upper end. The line of spots across upper part of plate about 6 in. from top may be due to accidental abrasion. Otherwise better than No. 1.

SERIES B.—TESTS ON OLD STEEL.

TEST No.	DESCRIPTION.	CONDITION AT ALTOONA ON FEB. 27, 1919.	CONDITION AT BROOKLYN ON FEB. 28, 1919.
12	About 25 per cent of surface bare and rusted; old paint on balance. Cleaned with wire brush only, leaving old paint on about 50 per cent of surface. Painted in warm, dry room.	No appreciable change from 1918 inspection. Has same surface characteristics as noted in 1918 for panel No. 13. Metal fully protected and paint film unbroken. Condition generally about as good as Nos. 13, 14 and 15, but blisters noted in the 1918 report have not progressed and may be simply rough spots on the original surface.	Some rust inside clamp lines; otherwise, general condition good. No appreciable change from 1918 inspection.
13	About 25 per cent of surface bare and rusted in spots, old paint on balance. Washed with benzine, scraped and wire-brushed, leaving old paint on about 50 per cent of surface. Painted in dry, warm room.	No appreciable change from 1918 inspection. Metal fully protected and paint film unbroken.	No appreciable change from 1918 inspection.

SERIES B—(*Continued*).

TEST No.	DESCRIPTION.	CONDITION AT ALTOONA ON FEB. 27, 1919.	CONDITION AT BROOKLYN ON FEB. 28, 1919.
14	Approximately 10 per cent of surfaces bare and rusted in spots, old paint on balance. Brush-coated with benzine over and around rust spots and benzine burned off with torch flame. Surface then scraped and wire-brushed. Painted in warm, dry room.	No appreciable change from 1918 inspection.	No appreciable change from 1918 inspection, except 1¼ in. broken rust blister at center of panel.
15	Plates badly indented at several points, apparently by blows of a pick or other similar instrument. Approximately 50 per cent of surfaces bare and rusted. Sand-blasted in warm, dry room and painted therein about 3 hr. later.	No appreciable change from 1918 inspection.	Break in film at apex of indentation same as noted in 1918 inspection; possibly extended. A few scattered pin-head rust spots; in general comparable with No. 1.

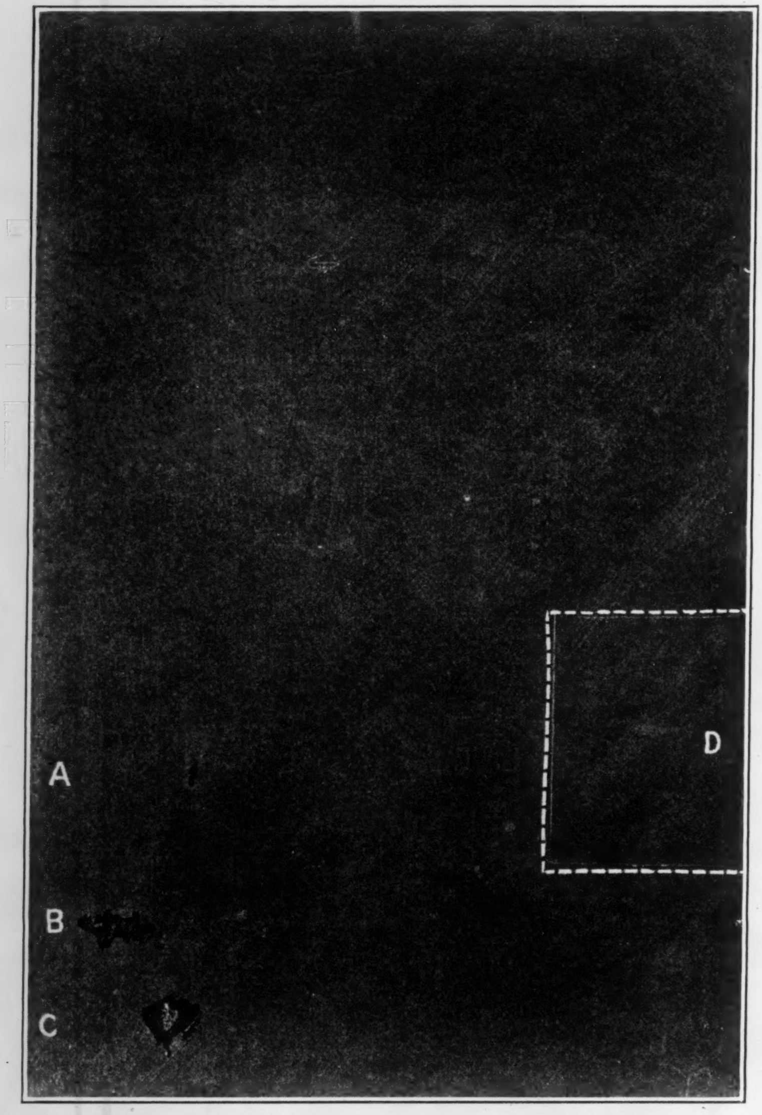

FIG. 1.—Entire Panel No. 10 at Altoona, March 22, 1919.

Breaks in coating opposite letters A, B and C made or extended by scraping in the examination, were recoated with varnish. The rectangular section outlined opposite the letter D is the section photographed full-size in report of 1918 and in present report (Fig. 2).

FIG. 2.—Full-Size Section, Panel No. 10 at Altoona, March 22, 1919.
(See D, Fig. 1.)

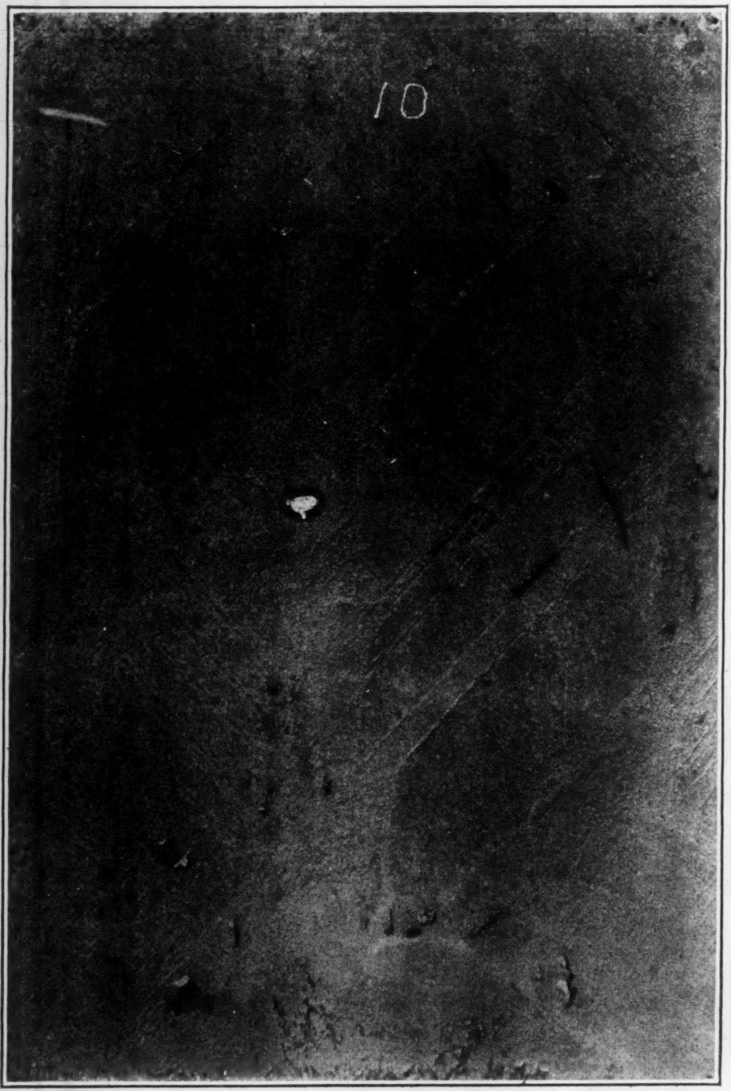

FIG. 3.—Entire Panel No. 10 at Brooklyn, March, 1919.

Spot near center of plate shows light-colored paint applied to surface where scraped in the examination.

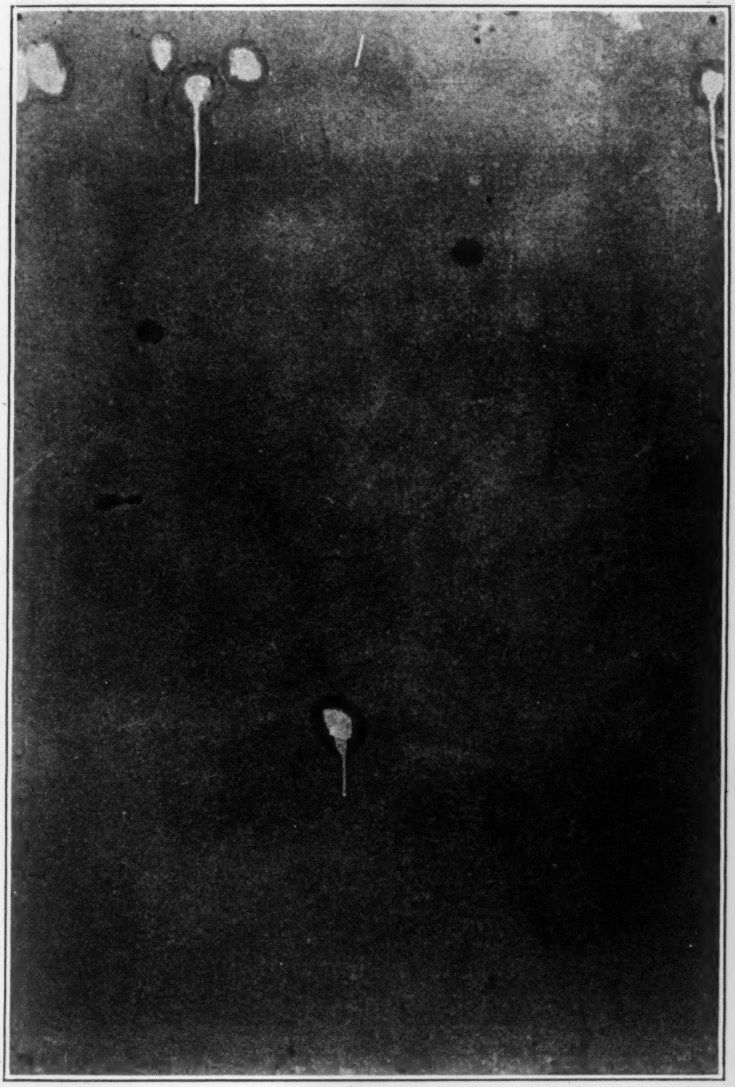

FIG. 4.—Entire Panel No. 1 at Brooklyn, March, 1919.

Light-colored spots are paint applied to re-coat the surface where scraped in the examination.

REPORT OF SUB-COMMITTEE XVI ON TERMS USED IN REPORTING THE SERVICE CONDITION OF PAINTED SURFACES.

The purpose of this sub-committee is the standardization of terms for reporting the condition of painted surfaces after exposure. It is important that uniform, precise and relatively accurate methods for describing or measuring the character and amount of disintegration of paint coats be adopted. Unless such standards are evolved, reports made on the wearing values of paints by different investigators or observers cannot be intelligently or accurately compared.

In considering the adoption of definitions for terms generally used in reporting condition of painted surfaces, descriptive words now in common use have been adhered to. In addition, an effort has been made to assign numerical values to these descriptive terms with the idea of ultimately working out some scheme whereby paint tests may be given a definite rating. A great deal of study is still required in order to assign values to the descriptive terms, so that the final rating may not only be an accurate one, but that it may really represent some well-balanced and understandable relative measure of service value.

Checking.—Checking describes slight breaks in the paint coat which do not extend through to the surface painted. This is reported and rated as:

Absent	10.0
Very Slight	9.9 to 8.0
Slight	7.9 to 6.0
Considerable	5.9 to 4.0
Bad	3.9 to 2.0
Very Bad	1.9 to 0.0

Alligatoring.—Alligatoring describes an aggravated form of checking. The breaks in the paint coat are wider than in checking and usually extend almost through to the surfaec painted. While the condition is seldom observed, it is advisable to include the term "Alligatoring" in the list of definitions. This condition is reported and rated same as for "checking."

Cracking.—Cracking describes a break which extends down to the surface painted. It may be a break which immediately extends down to the surface painted or it may be the development of what was first checking or alligatoring.

On wood, cracking is usually parallel with the grain, although sometimes it is at right angles to the grain. This condition is reported and rated same as for "checking."

Flaking.—Flaking describes the falling away of small pieces of the paint coat. This type of disintegration is generally the result of checking which gradually develops into cracking, ending in the crumbling of the paint coat. This condition is reported and rated same as for "checking."

Scaling.—Scaling describes the breaking away of pieces of paint of considerable size. This condition is generally the result of long cracks, on wood, usually parallel with the grain. This condition is reported and rated same as for "checking."

Blistering.—Blistering describes a condition where the paint coat is detached and raised from the surface over which it is applied, due to the formation of gases beneath the coating, influenced generally by moisture behind the coating.

The breaking of the blister results in peeling of the paint coat.

Peeling.—Peeling describes the pulling away or falling away of large pieces of the paint coat from the surface to which it was applied.

Peeling of paint is not the result of natural wear, but is due to improper application or to adverse conditions at the time of painting, such as moisture behind the paint coat or a faulty application of the priming coat.

Gloss.—Although much depends upon the nature of the coat, it is not advisable to report condition of gloss after a paint has weathered for more than a year. The gloss which a paint had shortly after its application disappears in proportion to the chalking of the paint, and while it is possible to restore a gloss to a surface in some cases, by rubbing, the gloss restored is the result of abnormal treatment. Gloss may be reported as:

Very Good	10
Good	9.9 to 8.0
Considerable	7.9 to 6.0
Slight	5.9 to 4.0
Very Slight	3.9 to 2.0
Absent	1.9 to 0.0

Chalking.—Chalking describes the reduction of the outer surface of the paint coat to a powdery substance, which may be removed by rubbing the coating with the dry finger, or a piece of soft, dark colored cloth, preferably black velvet. This condition is reported as follows:

Absent
Very Slight
Slight
Considerable
Heavy
Very Heavy

It is a difficult matter to assign uniformly satisfactory ratings to the qualifying terms and, therefore, while the report should include the item of "chalking," it is considered advisable to eliminate ratings.

Hiding.—Hiding is judged entirely by the degree of concealment of the surface painted. This property is frequently referred to as "covering," which more correctly applies to the area over which a given amount of paint will spread. Hiding is reported as follows:

Very Good	10
Good	9.9 to 8.0
Fair	7.9 to 6.0
Poor	5.9 to 4.0
Very Poor	3.9 to 2.0
None	1.9 to 0.0

Color.—Paints are divided into three classes, whites, tints and colors. The degree of whiteness determines the character of report for the first class. Two things generally influence color; first, the hiding power, and second, chalking. Invariably a paint that chalks presents a better color than one that does not. The impression gained through the eye serves as the basis for report regarding the color of paint. The original appearance need not be considered. While all colors show a natural fading out, some retain a pleasing tone while others appear distinctly muddy or lack the brilliance shown when first applied. The terms used for reporting color are:

Very Good
Good
Medium
Poor
Very Poor

It is not considered advisable to assign ratings to the descriptive terms.

General Appearance.—The general appearance of painted surfaces can really be determined only by viewing them from a distance of twenty or thirty feet, with the idea of forming an opinion as to whether the appearance is good, which will be influenced by such conditions as cracking, scaling, chalking, and other conditions usually found in paint wear.

Respectfully submitted on behalf of the sub-committee,

L. P. NEMZEK,
Chairman.

REPORT OF COMMITTEE D-2
ON
LUBRICANTS.

The committee has prepared a proposed Tentative Test for Viscosity which it presents to the Society with the recommendation that it be adopted as a tentative standard.

In this test the standard dimensions for the Saybolt Standard Universal Viscosimeter are those issued by the U. S. Bureau of Standards.

This report and the proposed Tentative Test for Viscosity of Lubricants have been submitted to letter ballot of the committee, which consists of 31 members; 27 ballots were returned and 4 members refrained from voting. The following is the result of the ballot:

	Affirmative.	Negative.	Not Voting.
General Report	27	0	4
Tentative Method for Viscosity	24	3	4

Respectfully submitted on behalf of the committee,

C. P. Van Gundy,
Chairman.

K. G. Mackenzie,
Secretary.

Editorial Note.

The proposed Tentative Test for Viscosity of Lubricants referred to in this report was accepted for publication as tentative and appears on pages 728–731.

DISCUSSION.

Mr. Flowers.

MR. A. E. FLOWERS.—This matter of a standard method of measuring viscosity has been brought before the Society for several years and the present committee report represents the committee's final conclusions. It seems to me that it is a little bit unfortunate that in the statements contained in the report, no mention is made of certain of the difficulties in the matter of choosing a standard instrument and putting it forth as approved by the Society. I refer particularly to the fact that the instrument gives readings that are not proportional directly to the viscosity throughout the range for which it is used. A great many people are conversant with that fact, but a great many other people are not, and it is unfortunate that our Society should put itself on record without at the same time pointing the limitations of the instrument. The fact that the readings are in seconds and not viscosities, not c.g.s. units, is a more or less minor matter; the fact that they vary with the density of the material used is again some objection, but not a major difficulty; but the fact that for some readings the instrument would have one multiplying factor to reduce its readings to absolute viscosity and throughout a considerable and much used range a very different and extremely variable multiplying factor to reduce the readings to actual viscosities, constitutes a very serious objection to the Saybolt Viscosimeter as a standard instrument, approved by this Society.

Mr. Mackenzie.

MR. K. G. MACKENZIE (*Secretary of Committee D-2*).—The Saybolt Standard Universal Viscosimeter is in very general use in this country in the testing of lubricants. It is used by the Navy Department and the War Department, and is also prescribed for certain of the other departments in specifications prepared by the United States Bureau of Standards. It has also been recommended by a special committee of railroad chemists for use in specifications covering purchases of all lubricants for the United States Railroad Administration. It has been standardized by the United States Bureau of Standards, and all

Mr. Mackenzie. owners of instruments can submit them to the Bureau and receive the Bureau's certificate.

It is only fair in this connection to speak of the careful and painstaking work of Dr. Herschel, of the Bureau of Standards, in collaboration with Mr. Saybolt, which has made this standardization possible.

EDITORIAL NOTE.

For a complete statement of the work which Committee D-2 on Lubricants has done on the subject of a Standard Test for Determination of Viscosity, reference should be made to the reports of Committee D-2 for 1914, 1915 and 1917 published in the Proceedings for those years as follows: Vol. XIV, Part I, pp. 356–373; Vol. XV, Part I, pp. 273–324; Vol. XVII, Part I, pp. 462–469.

REPORT OF COMMITTEE D-3

ON

METHODS OF SAMPLING AND ANALYSIS OF COAL.

Committee D-3 on Methods of Sampling and Analysis of Coal forms part of a joint committee on this subject with a committee of the American Chemical Society. In its annual report in 1916 the committee asked to be continued in order to consider several matters, among which was the fusibility of coal ash which had been referred to the joint committee by the American Chemical Society. During the past year a Method for the Determination of Fusibility of Coal Ash, proposed by Mr. A. C. Fieldner, Bureau of Mines, Pittsburgh, Pa., was submitted to the joint committee. This Method has been in use by the Bureau of Mines for several years and is described in Bulletin No. 129 of the Bureau of Mines, 1918. It has received the unanimous endorsement of the members of the joint committee and Committee D-3 accordingly recommends that it be published as a tentative standard of this Society, with the understanding that when it is finally adopted as standard it will be incorporated in the present Standard Methods for Laboratory Sampling and Analysis of Coal (D 22-16).[1]

This report has been submitted to letter ballot of the committee which consists of 4 members, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

S. W. Parr,
Chairman.

Editorial Note.

The proposed Tentative Methods for Determination of Fusibility of Coal Ash referred to in this report were accepted for publication as tentative and appear on pages 756–763.

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[1] 1918 Book of A.S.T.M. Standards, p. 679.

REPORT OF COMMITTEE D-4
ON
ROAD MATERIALS.

Committee D-4 herewith respectfully submits its report.

1. *Tentative Standard Recommended for Adoption without Change.*—It is recommended that the Tentative Tests for Determination of the Apparent Specific Gravity of Sand, Stone and Slag Screenings, and Other Fine Non-Bituminous Highway Materials (D 55-18 T)[1] be referred without change to letter ballot of the Society for adoption as standard.

2. *Revised Tentative Standard Recommended for Adoption.*—The Tentative Method for Determination of Softening Point of Bituminous Materials other than Tar Products (D 36-16 T)[2] has been revised. During revision careful consideration was given to a number of communications received from members of the Society. It is recommended that the revised method which is appended to this report[3] be referred to letter ballot of the Society for adoption as standard.

3. *Proposed Revision of Standard Test for Loss on Heating of Oil and Asphaltic Compounds (D 6-16).*[4]—Having received a number of comments and criticisms during 1919 relative to the description of this method, Committee D-4 has considered it advisable to describe the test in greater detail. The proposed revised test is appended to this report. The description of the old test has merely been elaborated and there is no essential change in the test itself. Committee D-4 recommends that the proposed revised test be published as tentative by the Society, with the understanding that it will be referred to letter ballot for adoption as standard when the Book of Standards is next republished.

4. *Proposed Tentative Method for Determination of Softening Point of Tar Products (Cube-in-Water Method).*—Committee

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part I, pp. 689–693 (1918).

[2] *Ibid.*, pp. 707–708.

[3] This Method is not reprinted here, but appears in the Supplementary Pamphlet of A.S.T.M. Standards Adopted in 1919.—Ed.

[4] 1918 Book of A.S.T.M. Standards.

D-4 recommends that this proposed new test appended to this report[1] be published by the Society as tentative before referring it to letter ballot of the Society for adoption as standard.

This method, substantially as described, has been satisfactorily used in the tar industry for a number of years. Therefore, the committee believes it advisable to adopt this method specifically for tar products rather than to attempt to use the ring and ball method. This fact was recognized when the ring and ball method was originally proposed for bituminous materials other than tar products.

5. *Proposed Tentative Specifications.*—It is recommended that the following tentative specifications appended hereto[2] be published as tentative before referring them to letter ballot of the Society for adoption as standard:

(*a*) Specifications for Materials for Cement Grout Filler for Brick and Stone Block Pavement.

(*b*) Specifications for Materials for Cement Mortar Bed for Brick, Stone Block and Wood Block Pavement.

(*c*) Specifications for Block for Granite Block Pavement.

Committee D-4 submits these specifications as the first of a series designed to cover various types of highway materials. It feels that in addition to standardization of tests there is great need of standardization of specifications for such materials. A number of its members are also members of other technical societies interested in the matter of specifications, so that the committee is enabled at all times to keep in close touch with the views and progress of these societies.

The results of the letter ballot of the committee upon the recommendations which have been made relative to the revision of old and the submission of new standards are as follows:

Recommendation.	Affirmative.	Negative.	Not voting.
TENTATIVE STANDARDS RECOMMENDED FOR ADOPTION.			
Proposed Tentative Tests for Determination of Apparent Specific Gravity of Sand, Stone and Slag Screenings, and Other Fine Non-Bituminous Highway Materials..........................	30	2	10
Revised Tentative Method for Determination of Softening Point of Bituminous Materials other than Tar Products..........	26	0	16

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[1] See pp. 764–767.—ED.

[2] See pp. 650–655.—ED.

Recommendation.	Affirmative.	Negative.	Not voting.
PROPOSED REVISION IN EXISTING STANDARD.			
Tentative Revision of Standard Test for Loss on Heating of Oil and Asphaltic Compounds	25	0	17
PROPOSED NEW TENTATIVE STANDARDS.			
Proposed Tentative Method for Determination of Softening Point of Tar Products (Cube in Water Method)	23	2	17
Proposed Tentative Specifications for Materials for Cement Grout Filler for Brick and Stone Block Pavement	23	10	9
Proposed Tentative Specifications for Materials for Cement Mortar Bed for Brick, Stone Block and Wood Block Pavement	23	10	9
Proposed Tentative Specifications for Block for Granite Block Pavement	27	2	13

This report has been submitted to letter ballot of the committee, which consists of 42 members, of whom 27 have voted affirmatively, 2 negatively, and 13 have refrained from voting.

Respectfully submitted on behalf of the committee,

A. H. BLANCHARD,
Chairman.

PRÉVOST HUBBARD,
Secretary.

EDITORIAL NOTE.

The Tentative Tests for Apparent Specific Gravity of Sand, Stone and Slag Screenings and Other Fine Non-Bituminous Highway Materials, and the revised Tentative Method for Determination of Softening Point of Tar Products referred to in this report were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1919, and appear in the Supplementary Pamphlet of A.S.T.M. Standards Adopted in 1919.

The revision in the Standard Test for Loss on Heating of Oil and Asphaltic Compounds referred to in the report was accepted as tentative, and the Test in revised form appears on pages 732–735.

The four proposed new tentative standards referred to in the report were accepted for publication as tentative and appear on pages 650–655 and 764–767.

REPORT OF COMMITTEE D-10
ON
SHIPPING CONTAINERS.

No meeting of this committee has been held since the last annual meeting of the Society. Much valuable information has been accumulated during the year by various members of the committee. Observations and records have been made as to the condition of the containers and their efficiency in both domestic and foreign commerce. Members of the committee have worked with both the War and Navy Departments, and have assisted the Railroad Administration on the preparation of specifications and designs of their containers and have made a special study of packing methods.

Most of these data are now available for use for the committee. The Forest Products Laboratory in cooperation with the War Department has been working upon the testing of containers, their design, specification and packing. The test data and results of this work are available for the committee. The laboratory is now cooperating with the War Department, Railroad Administration and, in accordance with former agreement, with the Society. This material is available for use of the committee.

The committee asks that the two Tentative Specifications for Canned Foods Boxes, D 44 - 17 T and D 45 - 17 T, be continued as tentative for another year.

A motion picture film of the box testing work at the laboratory will be presented to the Society as a supplement to this progress report.

This report has been submitted to letter ballot of the committee, which consists of 27 members, of whom 14 have voted affirmatively, 1 negatively, and 12 have refrained from voting.

Respectfully submitted on behalf of the committee,

J. A. Newlin,
Chairman.

W. S. Topping,
Secretary.

REPORT OF COMMITTEE D-11

ON

RUBBER PRODUCTS.

In spite of the handicaps under which most of us have been laboring during the past year, Committee D-11 can report substantial progress in its work.

The Tentative Specifications for Leader Hose for Use with Pneumatic Tools, prepared by Sub-Committee I, which were withdrawn from consideration by the Society at the last annual meeting, have now been redrafted into a form satisfactory to the committee and are appended to this report.[1] The committee recommends that they be accepted and published as tentative. The letter ballot vote of the committee on this recommendation is as follows: affirmative, 20; negative, 2; refrained from voting, 3; no reply, 6; total, 31.

Sub-Committee II last year presented Specifications for Rubber Belting for Power Transmission (D 53 – 18 T) which were adopted by the Society as tentative.[2] The committee now presents a number of revisions which are appended and recommends that the specifications as revised be continued as tentative. The letter ballot vote of the committee on this recommendation is as follows: affirmative, 21; negative, 2; refrained from voting, 2; no reply, 6; total, 31.

Sub-Committee III on Cold Water Hose, which has given some consideration to the subject of rubber-covered hose, has now definitely decided not to prepare specifications for this material as there appears to be little demand for it. Unless, therefore, a request for such specifications is received from the Society, the matter will be dropped.

This sub-committee, however, presents several revisions of the Standard Specifications for $2\frac{5}{8}$-in. Cotton Rubber-Lined Fire Hose for Private Department Use (D 14–15) and for $2\frac{1}{2}$, 3 and $3\frac{1}{2}$-in. Double-Jacketed Cotton Rubber-Lined Fire Hose for Public

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[1] See pp. 724–727.—Ed.

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part I, p. 676 (1918).

Fire Department Use (D 26–18).[1] These revisions[2] are considered to improve the specifications and the committee recommends that they be published as tentative until the Book of Standards is next reprinted. The letter ballot vote of the committee on this recommendation is as follows: affirmative, 22; negative, 0; refrained from voting, 3; no reply, 6; total, 31.

In accordance with the plan announced in last year's report, Sub-Committee VI on Packing, Gaskets and Pump Valves has been reorganized. The new sub-committee has made considerable progress in formulating specifications, but the field is a large and difficult one and no definite specifications are as yet ready for presentation.

In pursuance of the recommendation of Sub-Committee VII on Steam Hose, the committee recommends that the Tentative Specifications for Steam Hose (D 54–18 T)[3] be continued as tentative for another year.

Sub-Committee IX on Rubber Insulating Tape has now completed the preparation of specifications for Adhesive Insulating Tape, which are appended hereto[4] with the recommendation of the committee that they be accepted and published as tentative. The letter ballot vote of the committee on this recommendation is as follows: affirmative, 20; negative, 0; refrained from voting, 5; no reply, 6; total, 31.

This report has been submitted to letter ballot of the committee, which consists of 31 members, of whom 24 have voted affirmatively, none negatively, and 7 have refrained from voting.

Respectively submitted on behalf of the committee,

EDW. A. BARRIER,
Chairman.

S. C. POTTS,
Secretary.

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[1] 1918 Book of A.S.T.M. Standards.

[2] See p. 779.—ED.

[3] *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part I, p. 681 (1918).

[4] See Editorial Note, p. 399.—ED.

APPENDIX.

PROPOSED REVISION OF TENTATIVE SPECIFICATIONS FOR RUBBER BELTING FOR POWER TRANSMISSION (D 53-18 T).[1]

The committee recommends that the following revisions be made in these specifications, and the specifications as revised continued as tentative:

1. *Section 8.*—Change the length of sample of belting submitted for inspection from 36 to 30 in.

2. Add new Section 10 as follows:

> "10. The filler or weft strength of the cotton duck in the belting shall be determined as follows: A transverse strip 1½ in. wide shall be cut from the belting and opened up into its various plies. Each of these plies shall be ravelled down to a width of 1 in. and tested in a fabric testing machine, the minimum width of jaws of which is 1½ in., the distance between jaws 3 in., and the speed of separation of jaws 20 in. per minute. The tensile strength shall be at least 175 lb."

3. Change present Section 10 to Section 11, and change the length of specimens submitted for inspection from 36 to 30 in.

4. Change present Section 11 to Section 12 and reword Paragraph (*a*) as follows:

> "(*a*) The friction test or adhesion between the plies shall be conducted in the following manner: Test specimens, each 1 in. in width, two plies in thickness and at least 4 in. in length, shall be prepared in sufficient number to test the adhesion between all plies. These should be taken transversely for belting 4 in. and over in width and longitudinally for lesser widths. The two plies shall be separated for a distance of about 1½ in. and by means of these separated

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part I, p. 676 (1918).

ends, the test specimen shall be mounted freely between the upper fixed pair of jaws and the lower pulling pair of jaws, the latter weighted to 18 lb. The rate of separation under this test shall not be greater than 1 in. per minute."

Omit present Paragraphs (*b*) and (*c*) and add new Paragraph (*b*) as follows:

> "(*b*) A suitable friction testing machine where available may be used to make the above test, in which case the pull required to cause a stripping of 1 in. per minute shall be not less than 18 lb."

5. Change present Section 12 to Section 13, and reword Paragraph (*e*) as follows:

> "(*e*) The elongation at the breaking load shall be such that the original 2-in. gage length of the test specimen for the cover shall stretch to not less than 9 in. and for the beading to not less than 10 in."

6. Renumber following sections to conform with the changes n numbers above noted.

EDITORIAL NOTE.

The proposed Tentative Specifications for Leader Hose for Use with Pneumatic Tools referred to in this report were accepted for publication as tentative and appear on pages 724–727.

The proposed revisions in the Tentative Specifications for Rubber Belting for Power Transmission were approved at the annual meeting and the specifications in their revised form appear on pages 715–719.

The proposed revisions in the Standard Specifications for $2\frac{5}{8}$-in. Cotton Rubber-Lined Fire Hose for Private Department Use, and for $2\frac{1}{2}$, 3 and $3\frac{1}{2}$-in. Double-Jacketed Cotton Rubber-Lined Hose for Public Fire Department Use were accepted for publication as tentative and appear on pages 778 and 779.

The proposed Tentative Specifications for Adhesive Insulating Tape were referred back to the committee with directions to consult with Committees D-9 on Electrical Insulating Materials and E-2 on Electrical Standards (see Summary of the Proceedings, page 23).

REPORT OF COMMITTEE D-13
ON
TEXTILE MATERIALS.

On account of the war conditions which prevailed at the time it was impossible to hold the usual fall meeting of Committee D-13 in Boston. The spring meeting took place, by the courtesy of the United States Rubber Co., in the auditorium of their building, 1790 Broadway, New York City, on April 24, 1919. An extended discussion took place of the questions which have arisen in the use of the Tentative General Methods for Testing Cotton Fabrics (D 39–18 T)[1] which were proposed at the Atlantic City meeting last June. No formal papers were presented, but the chairman distributed reports of several groups of tests made at the Institute of Technology in relation to moisture and testing machine capacity.

LIST OF PROPOSED PERMANENT SUB-COMMITTEES.

The Advisory Board of Committee D-13 met before the general committee meeting, and appointed sub-committees to serve until June, 1920. It was voted to create a new sub-committee upon Yarn, Thread and Twine. The duties of the various sub-committees were defined as follows:

Sub-Committee I on Humidity.—The investigation, study, and discussion of all questions arising regarding the effect of moisture in fabrics, as well as its control, measurement and behavior in testing textiles.

Sub-Committee II on Specimens.—The investigation, study, and discussion of all questions affecting the size, shape, selection and character of textile test specimens.

Sub-Committee III on Testing Machines.—The investigation, study and discussion of all questions arising in connection with the machines used in making tests, including their design, adaptation, operation and possible errors.

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[1] *Proceedings*, Am. Soc. Test Mats., Vol. XVIII, Part I, p. 709 (1918).

Sub-Committee IV on Classification and Identification of Fibers and Fabrics.—The investigation, study and discussion of the problem of properly grouping the various kinds of fabrics under various headings for the purpose of providing appropriate general or specific methods of testing.

Sub-Committee V on Nomenclature.—The definition and standardization of the terms employed in relation to testing fabrics.

Sub-Committee VI on Imperfections and Tolerances.—The investigation, study and discussion of the various kinds of imperfections which exist in textile materials, together with their amount and limitations.

Sub-Committee VII on Yarn, Thread and Twine.—The investigation, study and discussion of all questions arising in regard to spun fibers before weaving.

The following topics were discussed by the committee as a whole before referring them to the proper sub-committee.

EFFECT OF MACHINE CAPACITY ON APPARENT STRENGTH OF TEXTILES.

The fact has often been noted that the maximum capacity of a testing machine affects the apparent tensile strength of a textile specimen. If textiles of low strength are broken on machines of high capacity the apparent strength runs higher than when the reverse is the case. It is evident from the character of the testing machines generally employed at present, namely, those of the pendulum type, that the time interval elapsing between the instant the tension is first applied and the moment of rupture varies widely. With a weak textile this interval would correspond to the time necessary to displace a heavy pendulum a very small amount from its vertical position. A strong textile, on the other hand, would require the displacement of the weight pendulum possibly as much as sixty degrees from the vertical and would consume a much longer space of time. Tension tests upon materials having the character of fabrics, depend very greatly for their result upon the interval which is allowed the fibers in the fabric to disentangle and separate. When the load is relatively slow in its application the fibers will separate at a much less load than formerly and produce rupture. When rupture is accomplished suddenly, the strength will manifestly be higher.

In order to investigate this question, the chairman tested three groups of thirty samples each of tire fabric under as widely varying conditions as possible in regard to machine capacity. The fabric selected was of approved quality made from carded Egyptian cotton to the usual specifications $\frac{11}{23}^{s}$ by $\frac{11}{23}^{s}$, 17¼ oz. per sq. yd. All the specimens were cut 1½ in. wide and ravelled to 23 threads. The specimens were all warp specimens and the same set of threads was chosen so as to give uniform results rather than a test upon the excellence of the fabric. The speed of the pulling jaw in each case was 12 in. per minute and the length of all specimens between the jaws was 3 in. Flat jaws were used, front and back, 2 in. wide. About 95 per cent of all the specimens broke in the center.

TABLE I.—TESTS SHOWING EFFECT OF MACHINE CAPACITY ON APPARENT TENSILE STRENGTH OF FABRICS.

Group.	Capacity of Machine, lb.	Average Apparent Tensile Strength, lb.	Average Time to Produce Rupture, seconds.	Percentage Increase in Strength, referred to Group I.
I	300	238	11	...
II	400	247	9.5	4.2
III	800	255	6.7	7.1

Group I.—The machine here used was a vertical one of approved design, having a capacity of 300 lb. It had recently been calibrated with dead weights and was believed to give correct results. The average of the thirty tests was 238 lb., the least value being 212 lb. and the greatest 256 lb.

Group II.—A horizontal machine having a capacity of 400 lb. was here used. This machine was adapted for the use of either one or two weights upon the pendulum; the lighter weight only was used in these tests to give the above capacity. The average of this group of tests was 247 lb., the least being 230 lb. and the greatest, 263 lb.

Group III.—The same horizontal machine as in Group II was here used with both weights upon the pendulum, giving a capacity of 800 lb. The average for the thirty tests under these conditions was 255 lb., the least value being 236 lb. and the greatest, 270 lb.

During all these tests the interval of time from the moment the load was applied to the instant of rupture was carefully noted and is given in Table I.

For the sake of uniformity, all of the specimens were conditioned for a period of over three hours in an atmosphere at 32 per cent relative humidity and 68° F. temperature. It is entirely apparent that the increase in tensile strength of the specimens is due to the varying time interval in producing rupture. While this is an unfortunate accompaniment in testing textiles, it is difficult to see where, with our present type of testing machines, it can be eliminated. It is not a very great error at best. In fact, it is very much less than the error due to moisture effects which are very frequently ignored.

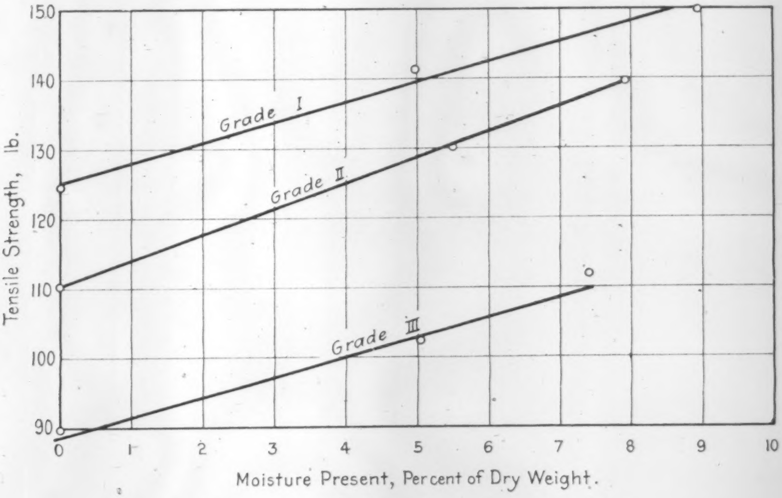

FIG 1.—Regain-Strength Plot for Gummed Cloth Tape.

It was suggested by the committee that future consideration be taken in regard to limiting the maximum capacity of the testing machine with regard to the average breaking strength of the fabric under consideration. This was, therefore, referred to Sub-Committee III on Testing Machines.

EFFECT OF MOISTURE UPON GUMMED CLOTH TAPE.

At the instance of the National Association of Corrugated Fiber Box Manufacturers which met in Cleveland on March 12, the chairman plotted a series of three moisture-strength diagrams for gummed cloth. The same effect was observed as in the case with ordinary fabric, the gain in strength being very uniform. Three conditions of moisture only were determined, namely, bone dry, natural, and at full regain. The latter was obtained by exposing the samples three hours in an atmosphere at a temperature of 70° F. and 65 per cent relative humidity. The law of increase is very uniform and amounts very nearly to 3 lb. increase in strength for each per cent of moisture present.

TABLE II.—TESTS OF GUMMED CLOTH TAPE.

Grade.	Condition.	Moisture, per cent.	Average Tensile Strength, lb.
I	Bone Dry	0	124.7
	Natural	4.96	141.2
	Full Regain	8.92	148.9
II	Bone Dry	0	110.2
	Natural	5.49	130.2
	Full Regain	7.90	139.5
III	Bone Dry	0	89.7
	Natural	5.02	102.6
	Full Regain	7.38	111.9

Table II gives the results of thirty tests each upon three typical grades of gummed cloth tape 2 in. wide. The plot shown in Fig. 1 exhibits the behavior of this material with reference to moisture.

VARIATION IN STRENGTH OF TEXTILES AT VARIOUS MOISTURE REGAINS, WITH RELATION TO THE WEIGHT OF THE FABRIC.

From practical laboratory experiments it has long been known that the rate of gain in tensile strength due to moisture absorption in various textiles bears a very direct relation to the weight of the fabric. While very heavy fabrics and those woven closely are slow in reaching their full regain, the increase in strength is very great. On the other hand, light fabrics of a gauze-like nature obtain their regains quickly and show but little increase in strength from this source. It is therefore manifestly incorrect to assume a standard rate of increase for all weights of textiles. In order to investigate this subject the chairman tested a variety of fabrics, ranging from a very open cheese cloth weighing about 1½ oz. per sq. yd. up to the heaviest obtainable duck, having a weight of about 50 oz. per sq. yd.

The fabrics were tested in groups of eight or ten specimens each at various regains, passing from a bone dry condition at one end of the scale to that at which all the moisture possible had been absorbed from an atmosphere having a relative humidity of 80 per cent. The moisture content was determined in each case by weighing on analytical balances before and after drying in an electric oven at a temperature of 220° F.

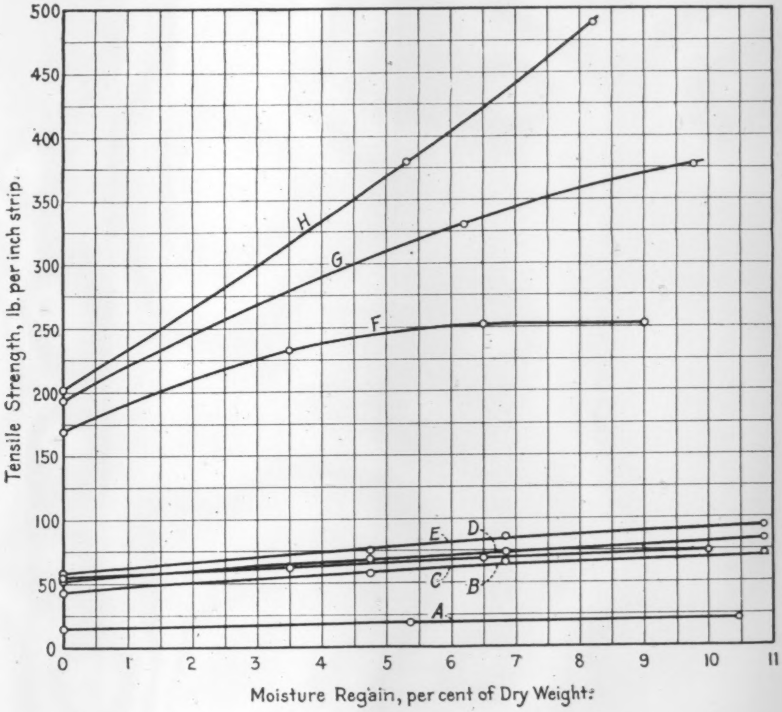

FIG. 2.—Variation in Tensile Strength in Textiles Due to Moisture.

The results are plotted in Fig. 2 and show to the same scale the wide range in strength increase with the various weights of fabric. In all cases strip specimens were used measured to $1\frac{1}{2}$ in. wide and ravelled accurately to 1 in. The distance between jaws was 3 in. in all cases and the speed of the moving jaw 12 in. per minute. While weighing, the moist specimens were in all cases enclosed in air tight containers, so that the moisture could not vary. The following is the detail of the tests:

Fabric A.—An open cheese cloth of ordinary grade cotton, 40 warp and 32 filling threads per inch, weighing bone dry 1.45 oz. per sq. yd. or, at a regain of 6 per cent, 1.54 oz.

Moisture, per cent	0	5.37	10.49
Average tensile strength, lb.	17.0	19.8	21.8

Fabric B.—30-in. 7-oz. Osnaburg. A very good standard fabric of this class. 40 warp by 30 filling threads per inch. The bone dry weight was 7.64 oz. per sq. yd. and, at 6 per cent regain, 8.10 oz.

Moisture, per cent	0	4.76	6.87	10.88
Average tensile strength, lb.	43.6	57.8	67.4	71.9

Fabric C.—Mercerized Cotton Airplane Wing Fabric. Normal weight 4 oz. per sq. yd.; $\frac{3}{80}^{s}$ yarn, with 68 threads per inch of width in both warp and filling.

The plot for this fabric is taken from a paper "The Effect of Moisture upon the Strength of Aircraft Fabrics," presented by the chairman at the June, 1918, meeting of the Society.[1]

Fabric D.—Cotton Bag Sheeting 48 by 48, 2.85-yd. goods 36 in. wide. This cloth weighed bone dry 5.17 oz. per sq. yd. and, at 6 per cent regain, 5.48 oz. per sq. yd.

Moisture, per cent	0	4.76	6.87	10.88
Average tensile strength, lb.	54.3	69.3	73.0	83.3

Fabric E.—30-in. 7-oz. Osnaburg. Exceptionally clean. The bone dry weight was 8.12 oz. per sq. yd. and, at 6 per cent regain, 8.60 oz.

Moisture, per cent	0	4.76	6.87	10.88
Average tensile strength, lb.	56.1	75.1	85.3	93.1

Fabric F.—Standard $\frac{11}{23}^{s}$ by $\frac{11}{23}^{s}$ square woven tire fabric, made of carded Egyptian cotton, $17\frac{1}{4}$ oz. per sq. yd. under normal conditions.

The plot for this fabric was originally derived by Messrs. Yeaton and Panettiere in the Textile Laboratory at the Massachusetts Institute of Technology. The plot was also presented by the author of the paper to which reference has just been made.

Fabric G.—A moderately heavy duck used in the manufacture of stitched canvas belts. The warp threads are 6 ply 26 per inch and the filling 5 ply

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part I, p. 380 (1918).

16 per inch. Bone dry the canvas weighed 27.5 oz. per sq. yd. and, at 6 per cent regain, 29.1 oz.

Moisture, per cent	0	6.23	9.79
Average tensile strength, lb	194	329	375

TABLE III.—STRENGTH INCREASE IN VARIOUS FABRICS FOR VARIOUS MOISTURE REGAINS.

Fabric.	Maximum Regain, per cent.	Rate of Increase in Per cent of Dry Strength for Each Per cent of Moisture.	Weight at 6 per cent Regain, oz. per sq. yd.
A—Cheese Cloth	10.49	2.69	1.54
B—Osnaburg	10.88	5.98	8.10
C—Wing Fabric	10.33	3.52	4.00
D—Sheeting	10.88	4.91	5.48
E—Osnaburg	10.88	6.06	8.60
F—Tire Fabric	9.00	6.67	17.3
G—Belt Duck	9.79	9.53	29.1
H—Heavy Duck	8.22	17.12	49.34

TABLE IV.—CORRECTION FOR VARIOUS WEIGHTS OF FABRIC.

Fabric.	Weight at 6 per cent Regain, oz. per sq. yd.	Correction Rate.
A—Cheese Cloth	1.54	0.57
B—Osnaburg	8.10	3.00
C—Wing Fabric	4.00	1.48
D—Sheeting	5.48	2.03
E—Osnaburg	8.60	3.18
F—Tire Fabric	17.3	6.40
G—Belt Duck	29.1	10.77
H—Heavy Duck	49.34	18.26

Fabric H.—A very heavy closely woven canvas. There were 19 threads per inch in the warp, 13 ply. The filling was made up of 15 threads per inch, 14 ply. Bone dry the canvas weighed 46.55 oz. per sq. yd. and, at 6 per cent regain, 49.34 oz.

Moisture, per cent	0	5.28	8.22
Average tensile strength, lb	204	381	491

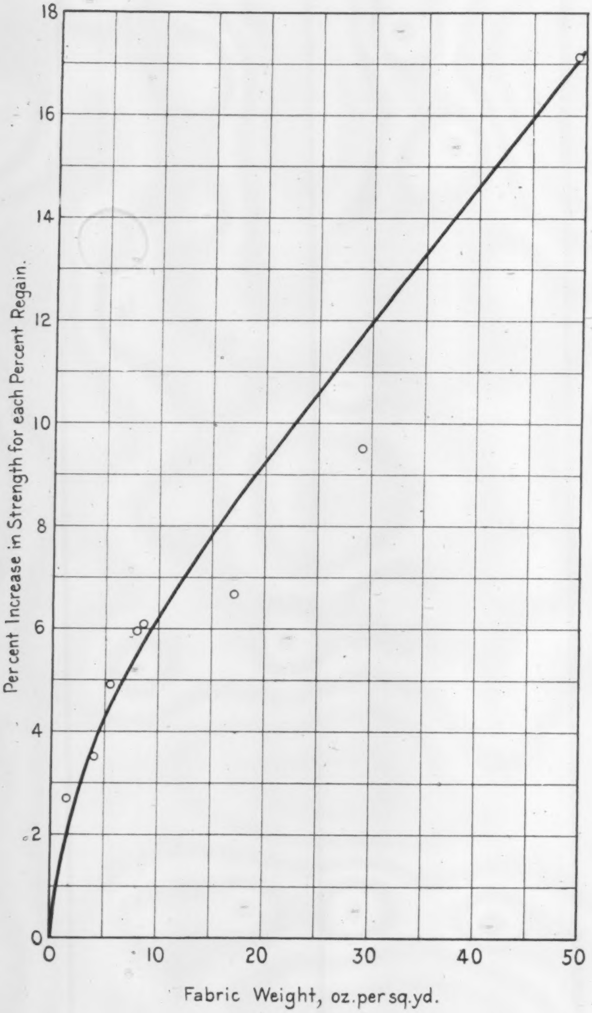

FIG. 3.—Rate of Increase in Tensile Strength with Relation to Weight of Fabric.

The lines plotted in Fig. 2 show that the strength increase in every case is fairly uniform and at the rates indicated in Table III.

The plot of Fig. 3 shows the rate of increase in relation to the weight of the fabric. Any expression or formula, therefore, to be used to correct apparent strengths for the moisture present must embody the weight of the fabric. The rate of increase in strength runs by approximately a straight line from 2.69 per cent for 1.54-oz. fabrics to 17.12 per cent for 49.34-oz duck. The rate of this increase is very nearly 0.37 per cent per ounce of fabric weight.

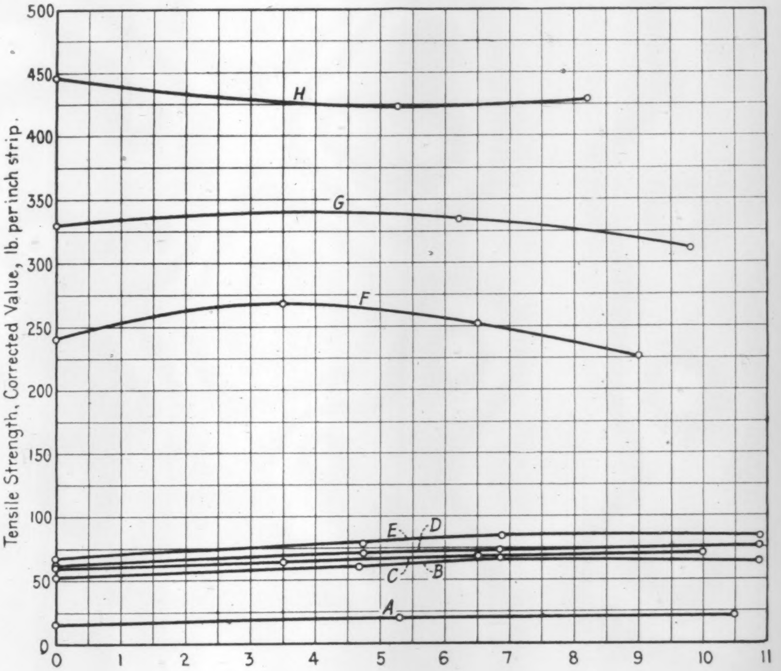

FIG. 4.—Tensile Strength of Fabrics Corrected for Moisture.

Therefore, there is for every weight of fabric a "correction rate" equal to 0.37 multiplied by its ordinary weight in ounces per square yard. For the fabrics given above this will be as shown in Table IV.

Thus to correct any cotton fabric for moisture present and bring it to a condition of $6\frac{1}{2}$ per cent standard regain, would require the use of a formula such as:

$$\text{Tensile Strength Corrected to Standard Moisture Regain of } 6\tfrac{1}{2} \text{ per cent} = \frac{\text{Tensile Strength from Machine Reading} \times [100 + (\text{Rate} \times 6.5)]}{100 + (\text{Rate} \times \text{Actual Regain at Test})}$$

If the above formula be applied to all the preceding tests the plot of Fig. 4 will be the result. This indicates a fair degree of uniformity in the results whatever the moisture content may be.

The above investigation was referred to Sub-Committee I on Humidity.

This report has been submitted to letter ballot of the committee, which consists of 38 members, of whom 26 have voted affirmatively, none negatively, and 12 have refrained from voting.

Respectfully submitted on behalf of the committee,

G. B. HAVEN,
Chairman.

D. E. DOUTY,
Secretary.

EDITORIAL NOTE.

The minor revisions in the Tentative General Methods for Testing Cotton Fabrics proposed when this report was presented at the annual meeting (see Summary of the Proceedings, page 23), were approved subject to a favorable letter ballot vote of the committee. This vote being favorable, the Methods in question appear in their revised form on pages 749–755.

REPORT OF COMMITTEE E-1
ON
METHODS OF TESTING.

Committee E-1 has held one formal meeting since the last annual meeting of the Society.

The committee has under consideration a number of subjects all of which are in the hands of sub-committees, which thus far have only made progress reports to the main committee. A portion of the work performed by these sub-committees will probably lead, by 1920, to the proposal of some tentative revision of existing standards or the development of some new standards, or both.

In the meantime, it is believed to be advisable to print as an appendix to this report the progress report of the Sub-Committee on Density in order to elicit discussion.

This report has been submitted to letter ballot of the committee, which consists of 36 members, of whom 26 voted affirmatively, none negatively, and 10 refrained from voting.

Respectfully submitted on behalf of the committee,

G. Lanza,
Chairman.

S. V. Hunnings,
Secretary.

APPENDIX.

STANDARDIZATION OF METHODS FOR THE DETERMINATION OF DENSITY.

By H. W. Bearce.

In any list of the physical characteristics of a substance, its density[1] or specific gravity[2] is usually included in the form of a numerical value. If these values are to be relied upon when obtained by different observers or by different methods, it is important that they be both accurate and comparable.

In this paper I shall point out some of the methods of observation and calculation which may be of service in obtaining results that are satisfactory in both of these respects.

In determining the density of solids and liquids, one of the following types of apparatus, or methods of measurement, is usually employed:

1. Picnometer (specific gravity bottle);
2. Hydrostatic weighing method;
3. Hydrometer;
4. Westphal apparatus;
5. Special apparatus.

The method to be employed in any given case is dependent upon the nature of the material whose density is to be determined and upon the precision of measurement required.

For determining the density of liquids any one of the above methods may be employed, while for solids either the method of hydrostatic weighing or special apparatus is nearly always employed, though in some special cases the picnometer is useful.

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[1] Density is the mass per unit of volume; it is usually expressed in grams per cubic centimeter (or per milliliter). The cubic centimeter (that is, the volume of a cube 1 cm. on a side) is not exactly equal to the milliliter, but the difference is so slight as to be negligible in all ordinary density determinations. The milliliter is equal to 1.000027 cubic centimeters. (See Travaux et Memoires du Bureau International des Poids et Mesures, XIV, 1910.) In all volumetric measurements the milliliter is the unit of volume employed, though it is referred to as the "cc." or the "ml." When the cubic centimeter is actually employed it should be written as "cm^3" and not as "cc."

[2] Specific gravity is an abstract number expressing the ratio of the weight of a certain volume of the material in question to the weight of the same volume of some other substance taken as standard at a stated temperature.

Density and specific gravity, while fundamentally different as pointed out in footnotes (1) and (2), are nevertheless determined in the same way and may have the same numerical values. The two terms are often used synonymously as expressing the "heaviness" of a substance. They may properly be so used if care is taken to state the units employed, but there is always danger of confusion and misinterpretation of results unless the units employed and the temperatures involved are clearly and definitely stated.

Specific gravity may be determined at any convenient temperatures and referred to water at any desired temperature. For example, specific gravity may be determined at 20° C. and referred to water at 20°, 15°, 4° C., or any other desired temperature. It is then expressed as specific gravity at 20°/20° C., 20°/15° C., or 20°/4° C. If determined at 25° C., the specific gravity is expressed as 25°/20° C., 25°/15° C., or 25°/4° C.

Specific gravity is often expressed in terms of water at the same temperature as that at which the substance is weighed; for example, 15°/15°, 20°/20°, 25°/25°. It is preferable, however, especially in the case of liquids, to express all specific gravities in terms of water at 4° C. The values are then directly comparable, since they are measured in terms of the same unit, and if the change of specific gravity per degree change of temperature is known they may all be easily reduced to the same temperature. There is also the additional advantage that specific gravities when so expressed are numerically the same as densities in grams per milliliter. For example, specific gravity at 25°/4° C. is numerically the same as density at 25° C. expressed in grams per milliliter.

PICNOMETER AND HYDROSTATIC WEIGHING METHODS.

In making specific gravity determinations on a series of samples of the same kind by means of a picnometer, it is likely that the temperatures of the various samples will differ somewhat unless a constant temperature bath is available. Suppose the temperatures range as follows: 23°.5, 24°.4, 25.°0, 25°.6, and 26°.2 C. The specific gravities may then be calculated at 23°.5/4°, 24°.4/4°, 25°.0/4°, 25°.6/4°, and 26°.2/4°, and, if the change of specific gravity per degree is known, the values can at once be reduced to 25°/4° by multiplying the change per degree by the difference between the temperature of observation and 25°. For example, if the samples are linseed oil, of which the change in specific gravity per degree Centigrade is 0.00068, the specific gravities can be reduced to 25°/4° by subtracting from the observed values of the successive samples 0.00068 times 1.5, 0.6, 0, –0.6, and –1.2.

If the above specific gravities had been expressed in terms of water at the temperature of observation, in each case they would have been at 23°.5/23°.5, 24°.4/24°.4, 25°/25°, 25°.6/25°.6, and 26°.2/26°.2°, and would not then have been directly comparable or easily reducible to the same basis, since the correction to be applied in each case would then involve both the expansion of the liquid itself and the change of the unit of measurement; that is, the density of water.

For purposes of comparison, specific gravities are sometimes shown in parallel columns at 15°/15° and at 25°/25°. This method does not make possible a real comparison since the values given in the two columns are measured in different units. It shows only the difference between the expansion of the liquid in question and that of water over the same temperature range. If it should happen that the liquid in question had the same rate of expansion as water then the two columns would be identical. That is, it would appear that the specific gravity of the liquid did not change with change of temperature.

In actually carrying out specific gravity determinations by means of a picnometer in such a way as to most easily reduce all determinations to the basis of 25°/4°, 20°/4° or other convenient basis, it will be found desirable to first calibrate the picnometer in such a way that the weight of water contained by it at all temperatures over the range covered, can be conveniently tabulated for ready reference. This can be done by determining the weight of water contained at any convenient temperature and from that finding the volume at that temperature by means of the known density of water, by means of the equation, $V = m/d$. The volume of the picnometer at other temperatures differing by 0°.1, or 0°.5 or 1°.0, as desired, can then be calculated by assuming that for ordinary glass the volume coefficient is 0.000023 per unit of volume per degree Centigrade. The weight of water required to fill the picnometer at any temperature can then be calculated by again using the table of water densities.

The specific gravity of a liquid at any temperature in the range covered by the picnometer calibration can then be calculated at once by dividing the weight of the liquid contained at any temperature by the weight of water at the same temperature. But if it is desired to express all specific gravities in terms of water at 4° C., it is then necessary to divide the weight of water at each temperature by the density of water at that temperature. This operation will have the effect of reducing again to the volume of water (or internal volume of the picnometer) at that temperature. It is apparent, therefore, that if the weight of the liquid contained in a picnometer at any temperature be divided by its volume at that temperature, the result will be the specific gravity of the liquid at that temperature in terms of water at 4° C. taken as unity. It will also be numerically the same as the density of the liquid at that temperature, in grams per milliliter.

A numerical example will make the matter clear:

Suppose a picnometer is found to hold 50.0000 g. of water at 20° C. Its volume will be $50.0000 \div 0.998234 = 50.0884$ ml., and at integral degrees between 18° and 25° C. will be as follows:

TEMPERATURE, $t°$ C.	VOLUME OF PICNOMETER, ml.	WEIGHT OF WATER, g.
18	50.0861	50.0172
19	50.0873	50.0089
20	50.0884	50.0000
21	50.0896	49.9906
22	50.0907	49.9806
23	50.0919	49.9702
24	50.0930	49.9592
25	50.0942	49.9478

Suppose that at 20° C. the linseed oil required to fill the picnometer has an apparent weight of 46.5000 g.; then the apparent specific gravity at 20°/20° is $46.5000/50.000 = 0.93000$. The specific gravity at 20°/4° can be calculated by multiplying 0.93000 by the density of water at 20° C., $0.93000 \times 0.9982343 = 0.92835$. The specific gravity at 20°/4° can be determined more directly by dividing the weight of the linseed oil at 20° C by the volume of the picnometer at 20° C., or $46.5000/50.0884 = 0.92835$.

To obtain the specific gravity at t°/t°, divide the weight of the substance at t° by the weight of water given in the third column opposite t°.

To obtain the specific gravity at $t^\circ/4^\circ$ C., divide the weight of the substance at t° by the volume of the picnometer given in the second column opposite t°.

To reduce the specific gravity at $t^\circ/4^\circ$ C. to $t_1^\circ/4^\circ$ C., multiply the change of specific gravity per degree change of temperature by the temperature difference and add the product to or subtract it from the specific gravity at $t^\circ/4^\circ$ C., depending upon whether t_1° is greater or less than t°.

In all of the foregoing discussions it has been assumed that apparent specific gravity was desired; that is, the apparent weights have not been corrected for the buoyancy of the air.

In case the true specific gravity is desired, this can be obtained either by correcting all weighings for air buoyancy before determining the ratio of the weights, or by applying a correction to the apparent specific gravity.

A convenient table is given in the U. S. Pharmacopœia (revision of 1910) for making this correction from apparent to true specific gravity. It is based on specific gravities at 25°/25° C., but is sufficiently exact for practical purposes at all ordinary laboratory temperatures. The table is as follows:

APPARENT SPECIFIC GRAVITY.	CORRECTION.	APPARENT SPECIFIC GRAVITY.	CORRECTION.
0.6	+0.00047	1	0.00000
0.7	+0.00035	2	−0.00118
0.8	+0.00024	3	−0.00236
0.9	+0.00012	4	−0.00353
1.0	0.00000	5	−0.00471
1.1	−0.00012	6	−0.00589
1.2	−0.00024	7	−0.00706
1.3	−0.00035	8	−0.00824
1.4	−0.00047	9	−0.00942
1.5	−0.00059	10	−0.01060
1.6	−0.00071	11	−0.01177
1.7	−0.00082	12	−0.01295
1.8	−0.00094	13	−0.01413
1.9	−0.00106	14	−0.01530
2.0	−0.00118	15	−0.01648

From an examination of the above table it will be seen that for substances whose specific gravity does not differ much from unity, the difference between apparent and true specific gravity is small; while for substances whose specific gravity is far from unity, the correction is correspondingly large.

In case it is desired to correct the apparent weight for air buoyancy, this correction may be calculated by means of an appropriate table of air densities at various temperatures and pressures. Such a table is given in Circular No. 19 of the Bureau of Standards. The buoyancy correction to be applied to any apparent weight, to reduce it to true weight in vacuo, is calculated by multiplying the air density by the difference in volume between the object weighed and the weights required to balance it on an even arm balance; or

$$B=\rho\ (V-V_w)$$

in which B=air buoyancy, ρ=air density, V=volume of object weighed, and V_w=volume of weights.

The numerical values of V and V_w will be arrived at by an approximation which may be carried to any desired degree of accuracy.

The value of V is equal to m/d, and for a first approximation m may be taken as the uncorrected weight, and d as the apparent specific gravity. In the same way V_w may be taken as the apparent weight divided by 8.4, the assumed density of the weights. This gives an approximate value for B which may be applied to the apparent weights and by this means a more exact value for V and V_w can be determined and with these values of V and V_w a more exact value of B can be obtained. This process may be continued until the successive values of V, V_w and B differ by negligible amounts. In most cases the second approximation will be found to be sufficiently exact, and in many cases, only the first approximation will be required.

For ordinary laboratory determinations of specific gravity by either the picnometer or the method of hydrostatic weighing, it will be found unnecessary to reduce from apparent to true specific gravity, since for liquids whose specific gravity is not far from unity, say from 0.8 to 1.2, the difference between apparent and true specific gravity is at most only about two units of the fourth decimal place. This difference is negligible in comparison with other errors that will ordinarily be made unless special precautions are taken.

Sources of Error.—The following are the principal sources of error in specific gravity determinations by means of the picnometer or the method of hydrostatic weighing:

(*a*) Errors in weighing;
(*b*) Errors in temperature measurement;
(*c*) Lack of proper wetting of sample;
(*d*) Lack of homogeneity of sample;
(*e*) Change of volume of picnometer;
(*f*) Evaporation of sample.

(*a*) *Effect of Errors in Weighing.*—The accuracy of specific gravity determinations is directly dependent upon the accuracy of the weighings on which the determinations are based, and any error in the determined weight, whether arising from improper filling of the picnometer, the presence of air bubbles, lack of proper cleaning of the outer surface of the picnometer, or from actual error in the operation of the balance, will result in a corresponding error in the specific gravity determination. The magnitude of the resulting error will depend upon the magnitude of the error in weight and upon the relation of this error to the total weight. For example, an error of 5 mg. on 50 g. will result in an error of 1 part in 10,000 in the specific gravity, while the same error on a weight of 5 g. will result in an error of 1 part in 1000. It is important, therefore, in all specific gravity determinations, whether by picnometer or by hydrostatic weighing, to use samples of such size that the unavoidable errors in weight will not result in greater errors than are permissible in the specific gravity.

If an ordinary 200-g. analytical balance is used, a mass of from 50 to 100 g. will usually be found satisfactory in the case of solids, and a picnometer having a capacity of 50 to 100 ml. in the case of liquids. The use of a small sample is, of course, sometimes made necessary by the nature of the material or lack of availability.

When the method of hydrostatic weighing is used, a sinker or plummet having a volume of about 50 to 75 ml. will be found convenient. In this connection mention should be made of the fact that in the method of hydrostatic weighing, errors are often introduced by the condition of the suspension wire at the point where it passes through the surface of the liquid. For accurate weighing the diameter of the wire should be as small as is consistent with safety and its surface should be either coated with platinum black or plated with unburnished gold. The apparatus should be so arranged that the wire passes through the liquid surface at all times when the same is being weighed in the liquid. This can easily be arranged by having a suitable yoke or basket into which the sample is slipped.

(*b*) *Effect of Errors in Temperature Measurement.*—One of the most frequent and troublesome causes of error in specific gravity determinations is inaccuracy of temperature measurement. In order for accurate determinations to be made, constant temperatures must be maintained and accurately measured. An error of 1° C. in the measured temperature of an oil or similar liquid will result in an error of from 0.0006 to 0.0008 in the specific gravity value determined. An equal error in the temperature of the water used in calibrating the picnometer will result in an error of about 0.0002 if the calibration is made at about 20° C. If the two errors happen to be in opposite directions the resulting error in specific gravity will be equal to the sum of the two while if they are in the same direction it will be equal to their difference.

(*c*) *Errors Due to Lack of Proper Wetting of the Surface.*—When a solid body is immersed in a liquid its surface is not, in general, completely and uniformly wetted by the liquid. This is especially true in the case of metals immersed in water. A thin film of air adheres to the surface, especially if it is rough or crystallin, and this gives an apparent volume of the solid that is incorrect. A specific gravity value based on this volume will, of course, be correspondingly incorrect.

This troublesome film of air may be avoided by the use of a liquid which completely wets the solid. The solid may be immersed and weighed in this liquid instead of in water as is ordinarily done; or the solid may be first wet with alcohol and the alcohol then washed off with water and the solid immersed in water while still wet. In case the solid is weighed in a liquid other than water in order to determine the specific gravity of the solid it is, of course, necessary to know the specific gravity of the liquid with sufficient accuracy for this purpose. This may be determined by weighing in the liquid a plummet or sinker of known mass and volume, or by means of the picnometer.

(*d*) *Errors Due to Lack of Homogeneity of Sample.*—In determining the density of a solid great care should be taken to insure that there are no voids or regions of non-uniform density within the sample. The result obtained by any method will be the ratio of the total mass to the total volume of the sample; that is, the average density of the entire sample; and if the particular sample in question has a void in its interior the average density determined will be lower than the true density of the material. The magnitude of the error will depend upon the relation of the volume of the voids to the total volume of the sample.

(*e*) *Change of Volume of Picnometer.*—Certain picnometers are so designed that a thermometer serves also as a ground-in stopper. The volume of the picnometer at any filling is dependent upon the force with which the stopper is pressed into place and it is exceedingly difficult to set it with uniformity. The result of this condition is that the actual volume of the picnometer when calibrated with water may, or may not, be the same as its volume when usd to determine specific gravity. Any lack of agreement in the volumes when calibrated and when used results in a corresponding error in the specific gravity determination.

(*f*) *Evaporation of Sample.*—Most picnometers are so designed that the liquid in the picnometer is in direct contact either with the ground glass joint or a hole drilled through the glass stopper. In either case an appreciable amount of evaporation of volatile liquid occurs while determinations are being made. This evaporation with its consequent errors is especially troublesome in the case of picnometers designed with a ground joint with which the liquid comes in contact. The evaporation can be largely overcome by suitable design such that the liquid comes in contact only with polished glass. A very satisfactory arrangement is one in which the picnometer terminates in a capillary tube over which a cap is fitted; the capillary tube extends into the cap a sufficient distance so that the liquid can be set flush with the tip of the capillary and the ground glass joint is back from the tip a sufficient distance so that the liquid in the picnometer does not creep back and come in contact with the ground joint.

HYDROMETER.

For use in determining the specific gravity of oils or other liquids of sufficient transparency and fluidity the hydrometer is well suited in case the accuracy required is within the range of the instrument. By the exercise of ordinary care in manipulation, a hydrometer which has been carefully calibrated should yield results that are accurate to one of the smallest subdivisions of its scale. For example, a so-called "precision" hydrometer should yield results that are accurate to one unit of the third decimal place, or, if graduated in percentages, to 0.1 per cent. By the exercise of special precautions as to temperature control, cleaning, etc., this degree of accuracy can be considerably improved upon.

WESTPHAL BALANCE.

The Westphal balance, while considerably used in determining the specific gravity of liquids, is not in general susceptible of great accuracy, and its calibration is unreliable and changeable. Its principal advantage is that it can be used on a sample of small volume. In general it is no more accurate than a hydrometer and not as convenient.

SPECIAL APPARATUS.

Special apparatus for determining density is usually designed to meet special requirements as to either accuracy or speed of operation. These requirements are in general mutually exclusive and the fulfilment of one means the sacrifice of the other. In the design and operation of such apparatus care should be exercised to maintain a proper balance between these two requirements.

A treatment of special apparatus will not be attempted in the present paper.

REPORT OF COMMITTEE E-4

ON

MAGNIFICATION SCALES FOR MICROGRAPHS.

Committee E-4 held one meeting during the year, at which nine members were present and six absent. The Definitions and Rules governing the Preparation of Micrographs of Metals and Alloys (E 2-18 T)[1] were gone over carefully, having in mind the various further suggestions and criticisms which have come to the attention of the committee since its last report. The committee accordingly offers the following amendments:

Section 1.—Leave out 150, 250, 750, and 1500, and insert 200, making the section read:

> "The standard magnifications for general use in making micrographs, expressed in diameters, shall be as follows: 10, 25, 50, 75, 100, 200, 500, 1000.

Sections 2 and 3.—Substitute for these sections the following:

> "2. For general use in Society reports, and for showing grain size, the following magnifications are recommended:

MATERIAL.	CAST.	WROUGHT.
Steel and Ferrous Materials......	100	100
Copper........................	50 and 100	75
Copper-Zinc Alloys.............	50 " 100	75
Copper-Nickel Alloys...........	50 " 100	200
Copper-Nickel-Zinc Alloys.......	50 " 100	200
Lead-Tin-Antimony Alloys[2]......	50 " 200	....

Section 4.—To paragraph (*a*) add the following:

"except in those special cases where the details of structure are to be illustrated."

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part I, p. 716 (1918).

[2] Including those containing small percentages of copper.

Add a new paragraph (*e*), as follows:

"(*e*) Photographs in which the magnification is less than 10 diameters are usually made with photographic lenses or single magnifiers. These will be considered as "macrographs."

With each macrograph should be printed an explanatory title, together with the actual magnifications, method of illumination, and general treatment indicating what the author desires to illustrate, so that it will not be necessary to refer to the text for general information."

Add to the footnote on "Grain-Size Measurements" the following:

"After considering various criticisms, owing to the fact that 75 diameters has become an established practice for use in illustrating the structure and grain size of wrought copper and the copper-zinc alloys, and that a large volume of work has been done using this magnification, it seems advisable to retain a magnification of 75 diameters for this class of material."

On account of probable changes, the committee recommends that these Tentative Definitions and Rules, as thus amended, be continued as tentative for at least one more year.

This report has been submitted to letter ballot of the committee, which consists of 15 members, of whom 12 have voted affirmatively, none negatively, and 3 have refrained from voting.

Respectfully submitted on behalf of the committee,

W. H. BASSETT,
Chairman.

EDITORIAL NOTE.

The proposed revisions in the Tentative Definitions and Rules governing the Preparation of Micrographs of Metals and Alloys referred to in this report were accepted at the annual meeting and the Definitions in their revised form appear on pages 768–773.

REPORT OF COMMITTEE E-6

ON

PAPERS AND PUBLICATIONS.

Since the last annual meeting there has been no occasion to hold a general meeting of Committee E-6. Its functions relative to the acceptance of papers have been discharged by the Advisory Committee and other members of the committee who have given individual expert advice. The committee has also received assistance of this kind from members of the Society not connected with the committee, for which it desires to record its appreciative acknowledgment.

The program this year is one of the most important and interesting ones in the history of the Society. In addition to the many important recommendations included in the reports of the standing committees, such subjects as the following are covered in the technical papers: Measurement of the mobility and yield value of paint, the development of deep etching tests of rails and forgings, modern high speed steel, fatigue and impact tests, testing apparatus, non-ferrous metals, and cement and concrete.

A Topical Discussion is scheduled on the subject of Magnetic Analysis, a field of investigation which gives great promise.

Arrangements have been made for a joint session with the American Concrete Institute devoted to Cement and Concrete, similar to the one held last year. A motion picture showing certain activities of the United States Forest Products Laboratory has been arranged for.

The program contains 26 committee reports and 23 papers, exclusive of the Topical Discussion on Magnetic Analysis, which will be formally introduced by the presentation of five papers. The Advisory Committee has had to decline several offers of papers received after the expiration of the limiting date announced in a circular to members. Of the 50 items on the program, all but three—one committee report and two papers—

have been preprinted for use at the meeting. These preprints aggregate 873 pages as compared with 870 pages preprinted last year.

The interest of the program is well attested by the volume of written discussion of certain of the papers which has been received by the committee for presentation during the meeting. It is estimated that the discussion thus received in advance comprises approximately 50 printed pages.

Three committee reports containing recommendations as to standards, namely, Committee C-1 on Cement, Committee C-7 on Lime, and Committee D-11 on Rubber Products, were received too late to be mailed four weeks in advance of the annual meeting as required in the Regulations Governing Standing Committees. A fourth report, that of Committee C-11 on Gypsum, was received by the required time of eight weeks in advance of the meeting, but was so voluminous that it was not found possible to print it in time to distribute it four weeks in advance of the meeting. Preprints of these four reports were mailed to the members on June 14; and since they have been received by the members in advance of the meeting, the committee recommends that this requirement of the Regulations be waived so that the recommendations in the reports may be considered at this meeting.

TABLE I.—COMPARATIVE DATA FOR PREPRINTS.

Year.	Preprints.			On Program, but not Preprinted, pages.
	Distributed in Advance, pages.	Not Distributed in Advance, pages.	Total, pages.	
1913	461	238	699	81
1914	668	260	928	11
1915	891	76	967	0
1916	846	91	937	0
1917	978	100	1078	0
1918	690	180	870	19
1919	646	227	873	50 (estimated)

The preprints distributed in advance of the meeting were mailed in three instalments, on April 30, May 27 and June 14. The comparative data for preprints since 1913, when preprinting was first undertaken on an extensive scale, are given in Table I.

This report has been submitted to letter ballot of the committee, which consists of nine members, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

C. L. WARWICK,
Chairman.

A.S.T.M.
TENTATIVE STANDARDS

CONSISTING OF

SPECIFICATIONS, TESTS, METHODS AND DEFINITIONS.

The term Tentative Standards is applied to proposed Standards which are printed for one or more years with a view of eliciting criticism, of which the committee concerned will take due cognizance before recommending final action towards their adoption as standard.

Members of the Society and others are invited to direct written criticism of any of these Tentative Standards to the officer of the appropriate committee whose name and address appear in the footnote to the title of each Tentative Standard.

AMERICAN SOCIETY FOR TESTING MATERIALS
PHILADELPHIA, PA., U. S. A.
AFFILIATED WITH THE
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS
FOR
STEEL TIE PLATES.[1]

Serial Designation: A 67 - 18 T.

These specifications are issued under the fixed designation A 67; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916; REVISED, 1917, 1918.

In view of the abnormal difficulty in obtaining materials in time of war, the rejection limits for phosphorus in acid steels shall be raised 0.01 per cent above the values given in these specifications. This shall be effective during the period of the war and until otherwise ordered by the Society.

1. These specifications cover two grades of steel tie plates, namely: soft and medium. The soft grade will be used unless otherwise specified. **Material Covered.**

I. MANUFACTURE.

2. The steel may be made by the Bessemer or open-hearth process. **Process.**

II. CHEMICAL PROPERTIES AND TESTS.

3. The steel shall conform to the following requirements as to chemical composition: **Chemical Composition.**

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. C. L. Warwick, Secretary of Committee A-1 on Steel, 1315 Spruce St., Philadelphia, Pa.

BESSEMER.	SOFT GRADE.	MEDIUM GRADE.
Carbon, per cent..........	not under 0.06	not under 0.12
Phosphorus, per cent......	not over 0.10	not over 0.10
OPEN-HEARTH.		
Carbon, per cent..........	not under 0.12	not under 0.20
Phosphorus, per cent......	not over 0.06	not over 0.06

Ladle Analyses.

4. (*a*) A carbon determination shall be made of each melt of Bessemer steel, and two analyses every 24 hours representing the average of the elements carbon, manganese, phosphorus and sulfur, contained in the steel, one for each day and night turn respectively. These analyses shall be made from drillings taken at least $\frac{1}{8}$ in. beneath the surface of a test ingot obtained during the pouring of the melts. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

(*b*) An analysis of each melt of open-hearth steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulfur. This analysis shall be made from drillings taken at least $\frac{1}{8}$ in. beneath the surface of a test ingot obtained during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

Check Analyses.

5. An analysis may be made by the purchaser from a finished tie plate representing each melt of open-hearth steel, and each melt or lot of 10 tons of Bessemer steel. The carbon content thus determined shall not be less than that specified in Section 3, and the phosphorus content shall not exceed that specified in Section 3 by more than 25 per cent.

III. PHYSICAL PROPERTIES AND TESTS.

Bend Tests.

6. The bend test specimens specified in Section 7 shall bend cold through 180 deg. around a pin the diameter of which is equal to the thickness of the specimen for the soft grade, and to twice the thickness of the specimen for the medium grade, without cracking on the outside of the bent portion.

Test Specimens.

7. Bend test specimens shall be taken from the finished tie plates, or from the rolled bars; and longitudinally with the

rolling. They shall be rectangular in section, not less than ½ in. in width between the planed sides, and shall have two parallel faces as rolled. They shall be free from ribs or projections. Where the design of the tie plates is such that the specimen cannot be taken between the ribs or projections, these ribs or projections shall, in preparing the specimen, be planed off even with the main surface of the tie plate.

Optional Bend Tests. 8. If preferred by the manufacturer and approved by the purchaser, the following bend test may be substituted for that described in Section 6:

A piece of the rolled bar shall bend cold through 90 deg. around a pin the diameter of which is equal to the thickness of the section where bent for the soft grade, and to twice the thickness of the section where bent for the medium grade, without cracking on the outside of the bent portion.

Number of Tests. 9. (*a*) One bend test shall be made from each melt of open-hearth steel, or from each melt or lot of 10 tons of Bessemer steel.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

IV. WORKMANSHIP AND FINISH.

Workmanship. 10. The tie plates shall be smoothly rolled, true to templet, and shall be straight and out of wind on the surface which will form the bearing for the rail. They shall conform to the dimensions specified by the purchaser, with the following permissible variations:

(*a*) For plates with shoulders parallel to the direction of rolling, a variation of $\frac{1}{32}$ in. in thickness, ⅛ in. in rolled width, and $\frac{3}{16}$ in. in sheared length will be permitted.

(*b*) For plates with shoulders perpendicular to the direction of rolling, a variation of $\frac{1}{32}$ in. in thickness, ⅛ in. in rolled width, and ¼ in. in sheared length will be permitted. The distance from the face of shoulder to the outside end of plate shall not vary more than ¼ in., and from the face of shoulder to the inside end not more than ½ in.

Finish. 11. The finished tie plates shall be free from burrs and other surface deformations caused by the shearing and punching;

they shall also be free from other injurious defects and shall have a workmanlike finish.

V. MARKING.

Marking. 12. The name or brand of the manufacturer, the section and the year of manufacture shall be rolled in raised letters and figures on the outside of the shoulder of the plates, and a portion of this marking shall appear on each finished tie plate.

VI. INSPECTION AND REJECTION.

Inspection. 13. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the tie plates ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the tie plates are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 14. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

(*b*) Tie plates which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing. 15. Samples tested in accordance with Section 5, which represent rejected tie plates, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

AMERICAN SOCIETY FOR TESTING MATERIALS

PHILADELPHIA, PA., U. S. A.

AFFILIATED WITH THE

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS
FOR
BOILER AND FIREBOX STEEL FOR STATIONARY SERVICE.[1]

Serial Designation: A 70 – 18 T.

These specifications are issued under the fixed designation A 70; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916; REVISED, 1917, 1918.

Material Covered. 1. These specifications cover two grades of steel for boilers for stationary service, namely: flange and firebox.

I. MANUFACTURE.

Process. 2. The steel shall be made by the open-hearth process.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition. 3. The steel shall conform to the following requirements as to chemical composition:

		FLANGE.	FIREBOX.	
Carbon	For plates ¾ in. or under in thickness	.....	0.12 – 0.25	per cent
	For plates over ¾ in. in thickness	.....	0.12 – 0.30	"
Manganese		0.30 – 0.60	0.30 – 0.60	"
Phosphorus	Acid	not over 0.05	not over 0.04	"
	Basic	" " 0.04	" " 0.035	"
Sulfur		" " 0.05	" " 0.04	"

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. C. L. Warwick, Secretary of Committee A-1 on Steel, 1315 Spruce St., Philadelphia, Pa.

Ladle Analyses.

4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 3. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

Check Analyses.

5. An analysis may be made by the purchaser from a broken tension test specimen representing each plate as rolled. The chemical composition thus determined shall conform to the requirements specified in Section 3.

III. PHYSICAL PROPERTIES AND TESTS.

Tension Tests.

6. (*a*) The material shall conform to the following requirements as to tensile properties:

	FLANGE AND FIREBOX.
Tensile strength, lb. per sq. in.	55 000 – 65 000
Yield point, min., " "	0.5 tens. str.
Elongation in 8 in., min., per cent	$\frac{1\,500\,000}{\text{Tens. str.}}$;

but for firebox steel not less than 24 per cent, subject to the modifications of Section 7.

(*b*) The yield point shall be determined by the drop of the beam of the testing-machine.

Modifications in Elongation.

7. (*a*) For material over $\frac{3}{4}$ in. in thickness, a deduction of 0.5 from the percentages of elongation specified in Section 6 (*a*) shall be made for each increase of $\frac{1}{8}$ in. in thickness above $\frac{3}{4}$ in., to a minimum of 20 per cent.

(*b*) For material $\frac{1}{4}$ in. or under in thickness, the elongation shall be measured on a gage length of 24 times the thickness of the specimen.

Bend Tests.

8. The test specimen shall bend cold through 180 deg. without cracking on the outside of the bent portion, as follows: For material 1 in. or under in thickness, around a pin the diameter of which is equal to the thickness of the specimen; and for material over 1 in. in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen.

Homogeneity Tests.

9. For firebox steel, a sample taken from a broken tension test specimen shall not show any single seam or cavity more than $\frac{1}{4}$ in. long, in either of the three fractures obtained in the test for homogeneity, which shall be made as follows:

The specimen shall be either nicked with a chisel or grooved on a machine, transversely, about $\frac{1}{16}$ in. deep, in three places about 2 in. apart. The first groove shall be made 2 in. from the square end; each succeeding groove shall be made on the opposite side from the preceding one. The specimen shall then be firmly held in a vise, with the first groove about $\frac{1}{4}$ in. above the jaws, and the projecting end broken off by light blows of a hammer, the bending being away from the groove. The specimen shall be broken at the other two grooves in the same manner. The object of this test is to open and render visible to the eye any seams due to failure to weld up or to interposed foreign matter, or any cavities due to gas bubbles in the ingot. One side of each fracture shall be examined and the lengths of the seams and cavities determined, a pocket lens being used if necessary.

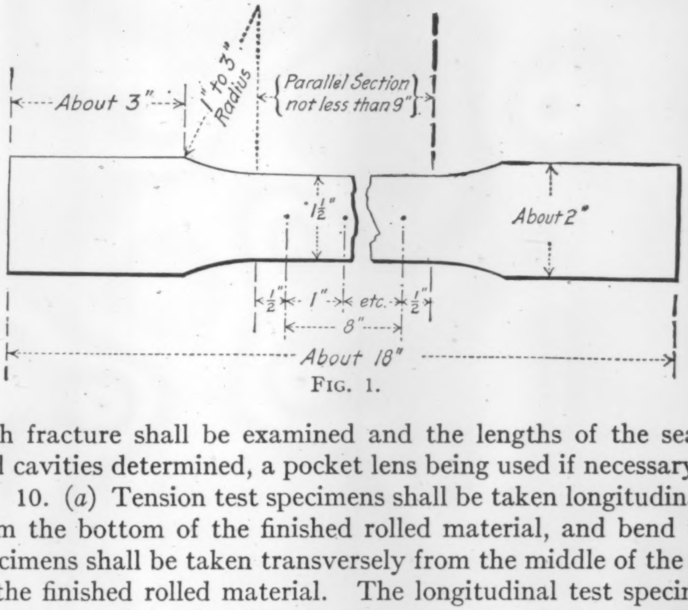

FIG. 1.

Test Specimens. 10. (*a*) Tension test specimens shall be taken longitudinally from the bottom of the finished rolled material, and bend test specimens shall be taken transversely from the middle of the top of the finished rolled material. The longitudinal test specimen shall be taken in the direction of the longitudinal axis of the ingot, and the transverse test specimen at right angles to that axis.

(*b*) Tension and bend test specimens shall be of the full thickness of material as rolled, and shall be machined to the form and dimensions shown in Fig. 1; except that bend test specimens may be machined with both edges parallel.

Number of Tests. 11. (*a*) One tension and one bend test shall be made from each plate as rolled.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 (*a*) and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

IV. PERMISSIBLE VARIATIONS IN WEIGHT AND THICKNESS.

Permissible Variations. 12. The thickness of each plate shall not vary more than 0.01 in. under that ordered.

TABLE I.—PERMISSIBLE OVERWEIGHTS OF PLATES ORDERED TO THICKNESS.

Ordered Thickness, in.	Permissible Excess in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Nominal Weights.									Ordered Thickness, in.
	Under 48 in.	48 to 60 in., excl.	60 to 72 in., excl.	72 to 84 in., excl.	84 to 96 in., excl.	96 to 108in., excl.	108 to 120in., excl.	120 to 132in., excl.	132 in. or over.	
Under 1/8	9	10	12	14	..	..	..	..	..	Under 1/8
1/8 to 3/16 excl.	8	9	10	12	..	..	..	..	..	1/8 to 3/16 excl.
3/16 " 1/4 "	7	8	9	10	12	..	..	..	..	3/16 " 1/4 "
1/4 " 5/16 "	6	7	8	9	10	12	14	16	19	1/4 " 5/16 "
5/16 " 3/8 "	5	6	7	8	9	10	12	14	17	5/16 " 3/8 "
3/8 " 7/16 "	4.5	5	6	7	8	9	10	12	15	3/8 " 7/16 "
7/16 " 1/2 "	4	4.5	5	6	7	8	9	10	13	7/16 " 1/2 "
1/2 " 5/8 "	3.5	4	4.5	5	6	7	8	9	11	1/2 " 5/8 "
5/8 " 3/4 "	3	3.5	4	4.5	5	6	7	8	9	5/8 " 3/4 "
3/4 " 1 "	2.5	3	3.5	4	4.5	5	6	7	8	3/4 " 1 "
1 or over	2.5	2.5	3	3.5	4	4 5	5	6	7	1 or over

The overweight of each lot[1] in each shipment shall not exceed the amount given in Table I. One cubic inch of rolled steel is assumed to weigh 0.2833 lb.

V. FINISH.

Finish. 13. The finished material shall be free from injurious defects and shall have a workmanlike finish.

VI. MARKING.

Marking. 14. (*a*) The name or brand of the manufacturer, melt or slab number, grade, and lowest tensile strength for its grade specified in Section 6 (*a*), shall be legibly stamped on each plate. The melt or slab number shall be legibly stamped on each test specimen.

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[1] The term "lot" applied to Table I means all of the plates of each group width and group thickness.

(*b*) When specified on the order, plates shall be match-marked as defined in Paragraph (*c*) so that the test specimens representing them may be identified. When more than one plate is sheared from a single slab or ingot, each shall be match-marked so that they may all be identified with the test specimens representing them.

(*c*) Each match mark shall consist of two over-lapping circles each not less than 1½ in. in diameter, placed upon the shear lines, and made by separate impressions of a single-circle steel die.

(*d*) Match-marked coupons shall match with the sheets represented and only those which match properly shall be accepted.

VII. INSPECTION AND REJECTION.

Inspection. 15. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 16. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 5, shall be reported within five working days from the receipt of samples.

(*b*) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing. 17. Samples tested in accordance with Section 5, which represent rejected material, shall be preserved for two weeks from date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

AMERICAN SOCIETY FOR TESTING MATERIALS

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TENTATIVE SPECIFICATIONS

FOR

CARBON TOOL STEEL.[1]

Serial Designation: A 71 - 17 T.

These specifications are issued under the fixed designation A 71; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

Material Covered. 1. These specifications cover carbon tool steel in ten classes and three grades, determined by the chemical composition specified in Section 3.

I. MANUFACTURE.

Process. 2. The steel shall be made by the crucible or electric process, with the exception of Grade C, which may be made by the open-hearth process.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition. 3. The steel shall conform to the following requirements as to chemical composition:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. C. L. Warwick, Secretary of Committee A-1 on Steel, 1315 Spruce St., Philadelphia, Pa.

ELEMENTS CONSIDERED.		GRADE A.	GRADE B.	GRADE C.
	CLASS No.			
Carbon, per cent	1	0.45 - 0.60	(Same as Grade A)	(Same as Grade A)
	2	0.60 - 0.75		
	3	0.75 - 0.90		
	4	0.90 - 1.05		
	5	1.05 - 1.20		
	6	1.20 - 1.35		
	7	1.35 - 1.50		
	8	1.50 - 1.65		
	9	1.65 - 1.80		
	10	1.80 - 1.95		
Manganese, max., per cent		0.40	0.45	0.60
Phosphorus, max., per cent		0.02	0.025	0.035
Sulfur, max., per cent		0.02	0.035	0.04
Silicon, max., per cent		0.35	0.35	0.25

Chemical Analyses. 4. In case of dispute, the chemical analyses shall be made in accordance with the Standard Methods for Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33)[1] of the American Society for Testing Materials.

III. PERMISSIBLE VARIATIONS IN DIMENSIONS.

Permissible Variations. 5. The permissible variations in the size of the material ordered shall be agreed upon by the contractor and the purchaser.

IV. FINISH.

Finish. 6. The material shall be free from injurious defects, and shall have a workmanlike finish.

V. MARKING.

Marking. 7. The identification marks to be placed on the material shall be agreed upon by the contractor and the purchaser.

VI. INSPECTION AND REJECTION.

Inspection. 8. The contractor shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection. 9. Material which does not conform to the chemical composition and agreed variations, or which shows injurious defects, will be rejected, and the contractor shall be notified.

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[1] 1918 Book of A.S.T.M. Standards.

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TENTATIVE SPECIFICATIONS
FOR
LOW-CARBON-STEEL TRACK BOLTS.[1]

Serial Designation: A 76 – 18 T.

These specifications are issued under the fixed designation A 76; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1918.

In view of the abnormal difficulty in obtaining materials in time of war, the rejection limits for phosphorus in acid steels shall be raised 0.01 per cent above the values given in these specifications. This shall be effective during the period of the war and until otherwise ordered by the Society.

I. MANUFACTURE.

Process. 1. (*a*) The steel may be made by the Bessemer or open-hearth process.

(*b*) The threads may be cut or rolled.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition. 2. (*a*) The steel for the bolts shall conform to the following requirements as to chemical composition:

Phosphorus	Bessemer	not over 0.10 per cent.
	Open-hearth	" " 0.05 "

(*b*) The steel for the nuts shall be "soft steel."

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. C. L. Warwick, Secretary of Committee A-1 on Steel, 1315 Spruce St., Philadelphia, Pa.

Ladle Analyses. 3. (*a*) A carbon determination shall be made of each melt of Bessemer steel, and two analyses every 24 hours representing the average of the elements carbon, manganese, phosphorus and sulfur, contained in the steel, one for each day and night turn respectively. These analyses shall be made from drillings taken at least $\frac{1}{8}$ in. beneath the surface of a test ingot obtained during the pouring of the melts. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 2.

(*b*) An analysis of each melt of open-hearth steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulfur. This analysis shall be made from drillings taken at least $\frac{1}{8}$ in. beneath the surface of a test ingot obtained during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 2.

Check Analyses. 4. An analysis may be made by the purchaser from a finished bolt representing each melt. The phosphorus content thus determined shall not exceed that specified in Section 2 by more than 25 per cent.

III. PHYSICAL PROPERTIES AND TESTS.

Tension Tests. 5. The stock from which the bolts are made shall conform to the following requirements as to tensile properties:

Tensile strength, lb. per sq. in	55 000 - 70 000
Elongation in 8 in., min., per cent...........	$\frac{1\ 500\ 000}{\text{Tens. str.}}$

Bend Tests. 6. The test specimen shall bend cold through 180 deg. flat on itself without cracking on the outside of the bent portion.

Test Specimens. 7. Tension and bend test specimens shall be taken from the full-size rolled bars. Tension test specimens shall be of 8-in. gage length.

Number of Tests. 8. (*a*) One tension and one bend test shall be made from each melt of steel. When the melts can not be identified, one tension and one bend test shall be made from each lot of 10 tons or fraction thereof.

(*b*) If any test specimen develops flaws, it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 5 and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

Retests. 9. If the results of the physical tests of any test lot do not conform to the requirements specified, two additional tension and two additional bend tests shall be made from such lot, all of which shall conform to the requirements specified.

IV. WORKMANSHIP AND FINISH.

Workmanship. 10. The bolts and nuts shall conform to the dimensions specified by the purchaser. They shall be neatly formed, free from fins or nickings. The head shall be concentric with, and firmly joined to, the body of the bolt, with the underside of the head at right angles to the body of the bolt. The threads shall be sharp and true to gage and of the pattern specified by the purchaser. The nuts shall fit the bolts hand free, two to six turns, and wrench tight the balance of the way without distorting the threads or twisting the bolts. The nuts shall be screwed on before shipping, a sufficient number of turns to hold them on to destination. A variation of $\frac{1}{32}$ in. under and $\frac{1}{64}$ in. over the specified diameter of the body of the bolt will be permitted. The diameter of the rolled threads shall not exceed the diameter of the body of the bolt more than $\frac{1}{16}$ in. for $\frac{7}{8}$-in. bolts and $\frac{3}{32}$ in. for 1-in. bolts. The length of the bolt under the head shall not vary more than $\frac{1}{8}$ in. from that specified. A variation in the dimensions of the elliptical shoulders under the head of the bolt of $\frac{1}{32}$ in. from the specified size will be permitted. A taper of the shoulder of $\frac{1}{32}$ in. will be permitted.

Finish. 11. The finished bolts and nuts shall be free from injurious defects and shall have a workmanlike finish.

V. MARKING.

Marking. 12. (*a*) A letter or brand indicating the manufacturer shall be pressed on the head of the bolt when it is formed.

(*b*) Bolts shall be packed in serviceable packages. All packages shall be plainly marked as to material, size of bolts and name of manufacturer.

VI. INSPECTION AND REJECTION.

13. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the bolts and nuts ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the bolts and nuts are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the works. **Inspection.**

14. Bolts and nuts which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified. **Rejection.**

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TENTATIVE SPECIFICATIONS
FOR
ELECTRIC CAST STEEL ANCHOR CHAIN.[1]

Serial Designation: A 77 – 18 T.

These specifications are issued under the fixed designation A 77; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1918.

Material Covered. 1. These specifications cover the cast steel to be used in all parts of the complete chain, including stud links, enlarged links, end links, shackles and shackle pins for anchor chain $1\frac{3}{8}$ in. and over.

I. MANUFACTURE.

Process. 2. (*a*) The steel shall be made by the electric furnace process, and all castings shall be produced in dry sand molds or cores.

(*b*) Each complete shot of chain shall be heat-treated in such manner that the treatment will be complete and uniform throughout its entire length.

Weight. 3. The weight of each shot of chain shall not be less than the minimum weight specified in Table I.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. C. L. Warwick, Secretary of Committee A-1 on Steel, 1315 Spruce St., Philadelphia, Pa.

II. PHYSICAL TESTS.

Test Chains.

4. (*a*) For each complete shot of 15 fathoms obtained there shall be cast two test chains consisting of at least one link from each heat entering into the production of that shot of chain. Each link in the test chains shall be properly marked for identification with the heat from which it is poured. The test chains shall contain not less than three links.

(*b*) Such test chains shall become the basis, as provided in Section 5, for the acceptance or rejection of the material entering into the shot of chain they represent.

TABLE I.—MINIMUM WEIGHT PER SHOT OF 15 FATHOMS.

Size of Chain, in.	Weight, lb.	Size of Chain, in.	Weight, lb.	Size of Chain, in.	Weight, lb.
$1\frac{3}{8}$	1 625	$2\frac{1}{8}$	3 785	$2\frac{7}{8}$	7 015
$1\frac{7}{16}$	1 775	$2\frac{3}{16}$	4 015	$2\frac{15}{16}$	7 330
$1\frac{1}{2}$	1 935	$2\frac{1}{4}$	4 245	3	7 650
$1\frac{9}{16}$	2 090	$2\frac{5}{16}$	4 485	$3\frac{1}{16}$	7 980
$1\frac{5}{8}$	2 235	$2\frac{3}{8}$	4 725	$3\frac{1}{8}$	8 320
$1\frac{11}{16}$	2 410	$2\frac{7}{16}$	4 960	$3\frac{3}{16}$	8 660
$1\frac{3}{4}$	2 590	$2\frac{1}{2}$	5 265	$3\frac{1}{4}$	9 010
$1\frac{13}{16}$	2 785	$2\frac{9}{16}$	5 535	$3\frac{5}{16}$	9 360
$1\frac{7}{8}$	2 975	$2\frac{5}{8}$	5 815	$3\frac{3}{8}$	9 725
$1\frac{15}{16}$	3 175	$2\frac{11}{16}$	6 105	$3\frac{7}{16}$	10 095
2	3 355	$2\frac{3}{4}$	6 405	$3\frac{1}{2}$	10 475
$2\frac{1}{16}$	3 570	$2\frac{13}{16}$	6 705	$3\frac{3}{4}$	12 025

(*c*) Both test chains shall be heat-treated with the complete shot of chain which they represent.

Breaking Tests.

5. (*a*) One of the test chains shall be pulled in an approved static testing machine to a breaking load in accordance with the loads specified in Table II. If this first test chain withstands the required tensile breaking load, the shot of chain which it represents shall be accepted so far as this test is concerned.

(*b*) If any link in the first test chain fails to withstand the required tensile breaking load, the second test chain shall be subjected to the same test. Prior to this retest the shot of chain and the second test chain may be subjected to a re-heat treatment at the option of the manufacturer. If the second test chain passes the required test the shot of chain which it represents shall be accepted so far as this test is concerned. If the second test chain fails to pass the required test the shot of chain shall be rejected.

Proof Tests. 6. (*a*) The complete shot of chain shall then be subjected to a proof test, which shall consist of anchoring each end thereof in an approved static testing machine and subjecting it to the proof load shown in Table II, according to its respective size. If the shot of chain passes this test it shall be accepted.

TABLE II.—PROOF AND BREAKING LOADS.

Size of Chain, in.	Proof Test, lb.	Breaking Test lb.	Size of Chain, in.	Proof Test, lb.	Breaking Test, lb.	Size of Chain, in.	Proof Test, lb.	Breaking Test, lb.
$1\frac{3}{8}$	114 000	160 000	$2\frac{1}{8}$	255 000	357 000	$2\frac{7}{8}$	431 500	604 000
$1\frac{7}{16}$	124 500	175 000	$2\frac{3}{16}$	270 000	378 000	$2\frac{15}{16}$	444 500	622 000
$1\frac{1}{2}$	131 500	184 000	$2\frac{1}{4}$	285 000	400 000	3	457 000	640 000
$1\frac{9}{16}$	137 500	193 000	$2\frac{5}{16}$	302 000	423 000	$3\frac{1}{16}$	469 500	658 000
$1\frac{5}{8}$	149 000	208 000	$2\frac{3}{8}$	318 500	446 000	$3\frac{1}{8}$	482 000	676 000
$1\frac{11}{16}$	160 500	225 000	$2\frac{7}{16}$	335 000	470 000	$3\frac{3}{16}$	494 500	693 000
$1\frac{3}{4}$	173 000	242 000	$2\frac{1}{2}$	353 000	494 000	$3\frac{1}{4}$	506 500	710 000
$1\frac{13}{16}$	185 500	260 000	$2\frac{9}{16}$	366 000	512 000	$3\frac{5}{16}$	518 500	726 000
$1\frac{7}{8}$	198 000	278 000	$2\frac{5}{8}$	379 000	531 000	$3\frac{3}{8}$	530 500	742 000
$1\frac{15}{16}$	211 500	296 000	$2\frac{11}{16}$	392 500	550 000	$3\frac{7}{16}$	541 500	758 000
2	226 000	316 000	$2\frac{3}{4}$	405 500	568 000	$3\frac{1}{2}$	553 000	775 000
$2\frac{1}{16}$	240 000	336 000	$2\frac{13}{16}$	418 500	586 000	$3\frac{3}{4}$	588 500	824 000

(*b*) If any link or links, not exceeding three in any one shot of 15 fathoms, fail during the proof test a new link or links may be cast in and the shot re-treated and again subjected to the proof tests. If it passes this retest the shot shall be accepted, provided the new link or links are poured from a heat represented in a test chain which had passed its prescribed breaking tests. If it does not pass this retest the shot shall be rejected.

(*c*) If more than three links of any one shot of 15 fathoms fail on proof test, the shot shall be rejected.

Shock Tests. 7. In addition to the breaking and proof tests specified in Sections 5 and 6, the material entering into the manufacture of the chain shall be subjected to such shock tests as shall be agreed upon between the manufacturer and the purchaser, in order to determine its shock-resisting qualities.

Use of Second Test Chain. 8. In the event that only one test chain is subjected to test, the remaining test chain may be united with and become a part of another complete shot of chain, and shall be considered acceptable although not represented by any link in the test chains for the new shot.

III. DIMENSIONS AND PERMISSIBLE VARIATIONS.

Dimensions. 9. All castings shall conform to the dimensions and permissible variations agreed upon between the manufacturer and the purchaser.

IV. FINISH.

Finish. 10. All castings shall be free from shrinkage, porosity or other injurious defects which would affect the strength of the chain, and shall have a workmanlike finish.

V. MARKING.

Marking. 11. Each shot of chain accepted shall be legibly stenciled in accordance with the requirements of the purchaser.

VI. INSPECTION.

Inspection. 12. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the chain ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the chain is being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

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TENTATIVE SPECIFICATIONS
FOR
STEEL PLATES FOR FORGE WELDING.[1]

Serial Designation: A 78 – 19 T.

These specifications are issued under the fixed designation A 78; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

Material Covered. 1. These specifications apply to steel plates for forge welding for tank cars and for similar construction.

I. MANUFACTURE.

Process. 2. The steel shall be made by the open-hearth or any other process approved by the purchaser.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition. 3. (*a*) The steel shall conform to the following requirements as to chemical composition:

Carbon	not over 0.18 per cent.
Manganese	0.30–0.60 "
Phosphorus	not over 0.04 "
Sulfur	" " 0.05 "

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. C. L. Warwick, Secretary of Committee A-1 on Steel, 1315 Spruce St., Philadelphia, Pa.

(*b*) The composition of steel for forge-welding plates should preferably be free from silicon, nickel or chromium. Where these elements are present the maximum quantity of any one shall not exceed 0.05 per cent.

Ladle Analyses. 4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulfur. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

Check Analyses. 5. An analysis may be made by the purchaser from a broken tension test specimen representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 3.

III. PHYSICAL PROPERTIES AND TESTS.

Tension Tests. 6. (*a*) The material shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.	plates $\frac{3}{4}$ in. or under in thickness....	48 000
	plates over $\frac{3}{4}$ in. in thickness.....	45 000
Yield point, lb. per sq. in.	....	0.5 tens. str.
Elongation in 8 in., per cent.	....	$\frac{1\,500\,000}{\text{Tens. str.}}$

(*b*) The yield point shall be determined by the drop of the beam of the testing machine.

Modifications in Elongation. 7. (*a*) For material over $\frac{3}{4}$ in. in thickness, a deduction of 1 from the percentage of elongation specified in Section 6 (*a*) shall be made for each increase of $\frac{1}{8}$ in. in thickness above $\frac{3}{4}$ in., to a minimum of 20 per cent.

(*b*) For material under $\frac{5}{16}$ in. in thickness, a deduction of 2.5 from the percentage of elongation in 8 in. specified in Section 6 (*a*) shall be made for each decrease of $\frac{1}{16}$ in. in thickness below $\frac{5}{16}$ in.

Bend Tests. 8. The test specimen shall bend cold through 180 deg. flat on itself without cracking on the outside of the bent portion.

Test Specimens.

9. (*a*) Tension and bend test specimens shall be taken from the finished rolled material.

(*b*) Tension and bend test specimens, except as specified in Paragraph (*c*), shall be of the full thickness of material as rolled; and may be machined to the form and dimensions shown in Fig. 1, or with both edges parallel.

(*c*) Tension and bend test specimens for plates over $1\frac{1}{2}$ in. in thickness may be machined to a thickness of at least $\frac{3}{4}$ in. for a length of at least 9 in.

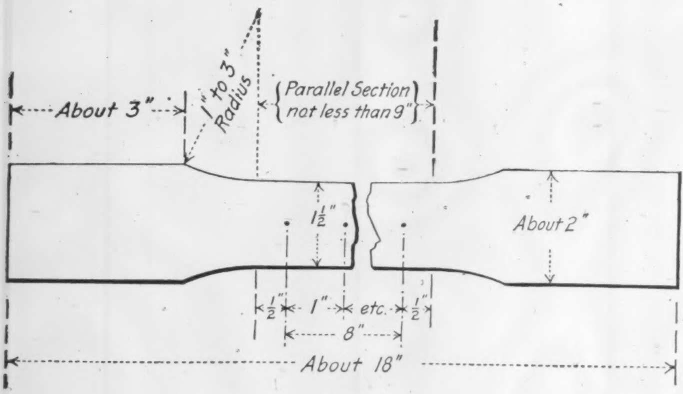

FIG. 1.

Number of Tests.

10. (*a*) One tension and one bend test shall be made from each melt; except that if material from one melt differs $\frac{3}{8}$ in. or more in thickness, one tension and one bend test shall be made from both the thickest and the thinnest material rolled.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 (*a*) and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

IV. PERMISSIBLE VARIATIONS IN WEIGHT AND THICKNESS.

Permissible Variation. 11. The cross-section or weight of plates shall be covered by the following permissible variations. One cubic inch of rolled steel is assumed to weigh 0.2833 lb.

(*a*) *When Ordered to Weight per Square Foot:* The weight of each lot[1] in each shipment shall not vary from the weight ordered more than the amount given in Table I.

(*b*) *When Ordered to Thickness:* The thickness of each plate shall not vary more than 0.01 in. under that ordered.

The overweight of each lot[2] in each shipment shall not exceed the amount given in Table II.

V. FINISH.

Finish. 12. The finished material shall be free from injurious defects and shall have a workmanlike finish.

VI. MARKING.

Marking. 13. The name or brand of the manufacturer and the melt number shall be legibly rolled or stamped on all finished material. The melt number shall be legibly marked, by stamping if practicable, on each test specimen.

VII. INSPECTION AND REJECTION.

Inspection. 14. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

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[1] The term "lot" applied to Table I means all of the plates of each group width and group weight.

[2] The term "lot" applied to Table II means all of the plates of each group width and group thickness.

TABLE I.—PERMISSIBLE VARIATIONS OF PLATES ORDERED TO WEIGHT.

ORDERED WEIGHT, LB. PER SQ. FT.	PERMISSIBLE VARIATIONS IN AVERAGE WEIGHTS PER SQUARE FOOT OF PLATES FOR WIDTHS GIVEN, EXPRESSED IN PERCENTAGES OF ORDERED WEIGHTS.																		ORDERED WEIGHT, LB. PER SQ. FT.
	Under 48 in.		48 to 60 in., excl.		60 to 72 in., excl.		72 to 84 in., excl.		84 to 96 in., excl.		96 to 108 in., excl.		108 to 120 in., excl.		120 to 132 in., excl.		132 in. or over.		
	Over.	Under.	Over.	Under.	Over.	Under.	Over.	Under.	Over.	Under.	Over.	Under.	Over.	Under.	Over.	Under.	Over.	Under.	
Under 5	5	3	5.5	3	6	3	7	3	...	...	...	...	...	...	...	...	...	...	Under 5
5 to 7.5 excl.	4.5	3	5	3	5.5	3	6	3	...	...	...	...	...	...	...	...	...	...	5 to 7.5 excl.
7.5 " 10 "	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	...	...	...	...	7.5 " 10 "
10 " 12.5 "	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	9	3	10 " 12.5 "
12.5 " 15 "	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	12.5 " 15 "
15 " 17.5 "	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	15 " 17.5 "
17.5 " 20 "	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	17.5 " 20 "
20 " 25 "	2	2	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	20 " 25 "
25 " 30 "	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	5	3	25 " 30 "
30 " 40 "	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	30 " 40 "
40 or over	2	2	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	40 or over

NOTE.—The weight per square foot of individual plates shall not vary from the ordered weight by more than 1½ times the amount given in this table.

TABLE II.—PERMISSIBLE OVERWEIGHTS OF PLATES ORDERED TO THICKNESS.

ORDERED THICKNESS, IN.	PERMISSIBLE EXCESS IN AVERAGE WEIGHTS PER SQUARE FOOT OF PLATES FOR WIDTHS GIVEN, EXPRESSED IN PERCENTAGES OF NOMINAL WEIGHTS.									ORDERED THICKNESS, IN.
	Under 48 in.	48 to 60 in., excl.	60 to 72 in., excl.	72 to 84 in., excl.	84 to 96 in., excl.	96 to 108 in., excl.	108 to 120 in., excl.	120 to 132 in., excl.	132 in or over.	
Under 1/8	9	10	12	14	..	..	..	..	..	Under 1/8
1/8 to 3/16 excl.	8	9	10	12	..	..	..	..	..	1/8 to 3/16 excl.
3/16 " 1/4 "	7	8	9	10	12	..	..	..	..	3/16 " 1/4 "
1/4 " 5/16 "	6	7	8	9	10	12	14	16	19	1/4 " 5/16 "
5/16 " 3/8 "	5	6	7	8	9	10	12	14	17	5/16 " 3/8 "
3/8 " 7/16 "	4.5	5	6	7	8	9	10	12	15	3/8 " 7/16 "
7/16 " 1/2 "	4	4.5	5	6	7	8	9	10	13	7/16 " 1/2 "
1/2 " 5/8 "	3.5	4	4.5	5	6	7	8	9	11	1/2 " 5/8 "
5/8 " 3/4 "	3	3.5	4	4.5	5	6	7	8	9	5/8 " 3/4 "
3/4 " 1 "	2.5	3	3.5	4	4.5	5	6	7	8	3/4 " 1 "
1 or over	2.5	2.5	3	3.5	4	4.5	5	6	7	1 or over

15. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples. **Rejection.**

(*b*) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

16. Samples tested in accordance with Section 5, which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time. **Rehearing.**

AMERICAN SOCIETY FOR TESTING MATERIALS

PHILADELPHIA, PA., U. S. A.

AFFILIATED WITH THE

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS
FOR
EXTRA REFINED WROUGHT-IRON BARS.[1]

Serial Designation: A 79 – 19 T.

These specifications are issued under the fixed designation A 79; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

Material Covered. 1. These specifications cover all rectangular bars over ½ in. and not over 4 in. in thickness.

I. MANUFACTURE.

Process. 2. The iron shall be made wholly from all-pig puddled iron and shall be free from any admixture of iron scrap or steel.

Definition of Terms. 3. *Iron Scrap*.—This term applies only to foreign or bought scrap and does not include local mill products free from foreign or bought scrap.

II. PHYSICAL PROPERTIES AND TESTS.

Tension Tests. 4. (*a*) The iron shall conform to the following requirements as to tensile properties:

Tensile strength, lb. per sq. in.	48 000 – 54 000
Yield point, min., " "	0.6 tens. str.
Elongation in 8 in., min., per cent	25
Reduction of area, min., "	37

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. H. E. Smith, Chairman of Committee A-2 on Wrought Iron, Box 491, Eleventh Street Station, Washington, D. C.

(*b*) The yield point shall be determined by the drop of the beam of the testing machine. The speed of the crosshead of the machine shall not exceed $\frac{3}{4}$ in. per minute.

Modifications in Tension Tests.

5. For material over 4 sq. in. in sectional area, the following deductions from the minimum requirements specified in Section 4 (*a*) shall be made for each square inch of nominal sectional area of material above 4 sq. in.:

Tensile strength	250 lb.,	but not under 46 000 lb.
Elongation	0.5 per cent,	" " " 22 per cent
Reduction of area	1 "	" " " 32 "

Bend Tests.

6. (*a*) *Cold-bend Tests.*—Cold-bend tests will be made only on bars having a nominal sectional area of 4 sq. in. or under, in which case the test specimen shall bend cold through 180 deg. without fracture on the outside of the bent portion, around a pin the diameter of which is equal to the thickness of the specimen.

(*b*) *Hot-bend Tests.*—The test specimen, when heated to a temperature between 1700° and 1800° F., shall bend through 180 deg. flat on itself without fracture on the outside of the bent portion.

(*c*) *Nick-bend Tests.*—The test specimen, when nicked along one side with a tool having a 60-deg. cutting edge, to depth of not less than 8 nor more than 16 per cent of the thickness of the specimen, and broken, shall show a wholly fibrous fracture.

(*d*) Bend tests may be made by pressure or by blows.

Etch Tests.[1]

7. The cross-section of the test specimen shall be ground or polished, and etched for a sufficient period to develop the structure. This test shall show the material to be free from steel.

Test Specimens.

8. (*a*) Tension test specimens shall be of the full section of material as rolled, if possible. Otherwise, the specimen shall be machined from the material as rolled; the axis of the specimen shall be located at any point midway between the center and edge and shall be parallel to the axis of the bar.

(*b*) Bend and etch test specimens shall be of the full section of material as rolled.

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[1] A solution of two parts water, one part concentrated hydrochloric acid, and one part concentrated sulfuric acid is recommended for the etch test.

Number of Tests.

9. (*a*) Bars of one size shall be sorted into lots of 100 each. Two bars shall be selected at random from each lot or fraction thereof, and tested as specified in Sections 4 and 6; but only one of these bars shall be tested as specified in Section 7.

(*b*) If any test specimen from either of the bars originally selected to represent a lot of material contains surface defects not visible before testing but visible after testing, or if a tension test specimen breaks outside the middle third of the gage length, the individual bar shall be rejected and one retest from a different bar will be allowed.

III. PERMISSIBLE VARIATIONS IN GAGE.

Permissible Variations.

10. The width or thickness of bars shall not vary more than 2 per cent from that specified.

IV. FINISH.

Finish.

11. The bars shall be smoothly rolled and free from slivers, depressions, seams, crop ends, and evidences of being burnt.

V. MARKING.

Marking.

12. The bars shall be stamped or otherwise marked as designated by the purchaser.

VI. INSPECTION AND REJECTION.

Inspection.

13. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

(*b*) The purchaser may make the tests to govern the acceptance or rejection of material in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

(*c*) All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

14. (*a*) If either of the test bars selected to represent a lot does not conform to the requirements specified in Sections 4, 5, 6 and 7, the lot will be rejected. **Rejection.**

(*b*) Unless otherwise specified, any rejection based on tests made in accordance with Section 13 (*b*) shall be reported within five working days from the receipt of samples.

(*c*) Bars which develop defects in forging or machining will be rejected, and the manufacturer shall be notified.

15. Samples tested in accordance with Section 13 (*b*), which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time. **Rehearing.**

AMERICAN SOCIETY FOR TESTING MATERIALS

PHILADELPHIA, PA., U. S. A.

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TENTATIVE SPECIFICATIONS

FOR

NON-FERROUS ALLOYS FOR RAILWAY EQUIPMENT IN INGOTS, CASTINGS, AND FINISHED CAR AND TENDER BEARINGS.[1]

Serial Designation: B 17 - 18 T.

These specifications are issued under the fixed designation B 17; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917; REVISED, 1918.

Material Covered.

1. (*a*) These specifications cover the various non-ferrous alloys for locomotive equipment in ingots, castings and finished car and tender bearings.

(*b*) These alloys and the purposes for which they are used are as follows:

Bearing Metal No. 1, for connecting-rod bearings, bushings, eccentric straps, crosshead gibs and miscellaneous bushings;

Bearing Metal No. 2, for driving-box bearings, engine-truck and trailer bearings, and hub liners;

Bearing Metal No. 3, for lead-lined bearings, for locomotive tenders, freight and passenger-car equipment;

Bell Metal, for locomotive bells only;

Babbitt Metal, for babbitting driving boxes, rod brasses, crossheads, and for hub liners;

Lining Metal, for lining truck brasses, tender brasses and car brasses.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

I. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition.

2. (*a*) The alloys shall conform to the following requirements as to chemical composition, with the permissible variations specified:

Alloy.	Copper, per cent.	Tin, per cent.	Lead, per cent.	Zinc, max., per cent.	Iron max., per cent.	Antimony, per cent.	Phosphorus, max., per cent.	Sulfur max, per cent.	Arsenic, max., per cent.	Total Impurities, including Zinc, max., per cent.
Bearing Metal No. 1........	remainder	9–11	9–11	0.75	0.25	0.25[a]	1.0[b]	....	....	1.0
Bearing Metal No. 2........	remainder	4–6	22.5-26.5	0.75	0.40	0.50[a]	....	....	....	1.5
Bearing Metal No. 3........	remainder	4–6	17–22	2.50	0.40	0.50[a]	....	....	....	3.0
Bell Metal.....	remainder	16–18	0.25[a]	0.25	0.25	0.25[a]	0.02	0.05	....	0.50
Babbitt Metal.	0.50[a]	9.25-10.75	remainder	none	....	14–16	....	....	0.20	0.75[c]
Lining Metal...	0.50[a]	4.50-5.50	remainder	none	....	9.25-10.75	....	....	0.20	0.75[c]

[a] Maximum.

[b] Not considered an impurity, and can be specified at option of purchaser.

[c] Must not contain zinc.

(*b*) Where no figures are given for impurity maximum, these elements may be present up to any amount to come within the total impurity specified, provided the material otherwise meets the chemical and physical tests. Where maximum percentages are specified, the elements referred to are considered as impurities and shall not be intentionally added.

Chemical Analysis.

3. An analysis will be made by the purchaser or his representative from one ingot, casting or journal bearing representing each lot. The chemical composition thus determined shall conform to the requirements specified in Section 2 for the particular alloy.

Sample for Chemical Analysis.

4. (*a*) *Ingots.*—Drillings shall be taken with a drill at least ½ in. in diameter at a point midway between the heaviest and smallest cross-section of the ingot. For ingots having two or more sections, drillings shall be taken from each section. In the case of Babbitt Metal and Lining Metal, drillings so taken shall be melted in a thoroughly cleaned ladle with a little rosin flux and poured into a piece of thin section. This piece shall be

sawed into three parts and the sawings therefrom thoroughly mixed to constitute the sample for chemical analysis.

(*b*) *Locomotive Castings.*—Drillings shall be taken with a drill as large as possible at such points in the casting as shall be thoroughly representative. Drillings through the skin shall be rejected. Drillings thoroughly mixed shall constitute the sample for chemical analysis.

(*c*) *Car and Tender Bearings.*—Drillings shall be taken with a drill at least ½ in. in diameter, at three points as widely separated as possible on the bearing selected for physical test as specified in Section 5 (*b*). Drillings representing the skin of the casting shall be rejected. These drillings, thoroughly mixed, shall constitute the sample for chemical analysis.

Drillings shall be taken in a like manner from the lining, exercising care that the drill does not penetrate the soldered surface.

(*d*) All samples, whether taken with a drill or saw, shall be kept free of oil and shall be carefully treated with a magnet to remove any iron introduced in taking the sample.

II. PHYSICAL INSPECTION AND TESTS.

Physical Inspection.

5. (*a*) *Locomotive Castings.*—The castings shall be sound, free from blowholes, flaws or shrinkage cracks, and shall show good foundry practice and workmanship.

One casting representing each lot of locomotive bearings will be broken by the purchaser or his representative for examination of fracture. The fracture shall disclose no shrink discoloration, segregation, dross or dirt spots within ⅝ in. of the bored journal engaging surface, and shall show no distinct signs of imperfect mixture.

(*b*) *Car and Tender Bearings.*—The bearings shall be sound, free from sand, blowholes, flaws or shrinkage cracks, and shall show good foundry practice and workmanship.

One bearing representing each lot will be broken by the purchaser or his representative for examination of fracture. The fracture shall show no shrink discoloration, segregation, dross or dirt spots within ½ in. of the bored journal engaging surface. This test shall be made before linings are applied. A second test shall be made after application of the lining as follows:

(1) The suspended brass when tapped with a hammer shall give a distinct ring.

(2) The lining when chipped with a cold chisel shall tear from the soldered surface as distinguished from clean shearing.

III. LOT.

Lot.

6. (*a*) *Ingots.*—Each 5000 lb. or fraction thereof shall constitute a lot. The ingot from which the sample is taken shall be included in the shipment.

(*b*) *Locomotive Castings.*—Unless otherwise specified, each 100 castings or fraction thereof shall constitute a lot.

The manufacturer shall furnish, free of cost, one casting representing each lot for purpose of tests as specified in Sections 4 (*b*) and 5 (*a*).

(*c*) *Car and Tender Bearings.*—Unless otherwise specified, each 300 bearings or fraction thereof from each pattern shall constitute a lot.

The manufacturer shall furnish, free of cost, one bearing representing each lot for purpose of tests as specified in Sections 4 (*c*) and 5 (*b*).

IV. PERMISSIBLE VARIATIONS IN DIMENSIONS.

(FOR CAR AND TENDER BEARINGS ONLY.)

Permissible Variations.

7. (*a*) The purchaser will furnish drawings showing the dimensions of the bearings ordered and permissible variations therefrom, and the bearings shall conform to these drawings within such permissible variations.

(*b*) The thickness at the center of the brass and of the complete bearing shall not vary more than $\frac{1}{32}$ in. over or under the normal thickness shown on the drawing. The thickness of the lining shall not vary more than $\frac{1}{32}$ in. over or under the normal thickness shown on the drawing.

V. WORKMANSHIP.

Workmanship.

8. (*a*) *Locomotive Castings.*—The castings shall conform to the dimensions specified and shall show good workmanship generally.

(*b*) *Car and Tender Bearings.*—The bearings shall show good workmanship generally, and shall be free from mechanical imperfections. They shall be bored to a true radius, and with the axis parallel to the plane of the top and perpendicular to the side lugs and bearing flange. The lettering shall be clear and distinct. No emery shall be used on journal engaging surfaces on either the brass or the lining.

VI. MARKING.

Marking.

9. (*a*) *Ingot.*—The manufacturer's marking only shall be required, unless otherwise specified.

(*b*) *Locomotive Castings.*—The lot number and other marks as required by the drawings shall be legibly marked on each casting.

(*c*) *Car and Tender Bearings.*—The name or initials of the manufacturer, the initials of the purchaser, type number, journal size, and lot number shall be legibly cast with raised figures on a depressed surface of each bearing, as shown on the drawings.

VII. INSPECTION AND REJECTION.

Inspection.

10. (*a*) Inspection may be made at the manufacturer's works where the ingots, locomotive castings or car and tender bearings are made, or at the point at which they are received, at the option of the purchaser.

(*b*) If the purchaser elects to have inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

11. Failure to meet the chemical or physical specifications, or non-conformity to any of the above requirements as to permissible variations, dimensions and markings, constitute sufficient cause for rejection of the lot represented by the sample chosen.

AMERICAN SOCIETY FOR TESTING MATERIALS

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TENTATIVE SPECIFICATIONS
FOR
BRONZE BEARING METALS FOR TURNTABLES AND MOVABLE RAILROAD BRIDGES.[1]

Serial Designation: B 22 - 18 T.

These specifications are issued under the fixed designation B 22; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1918.

Material Covered.

1. (*a*) These specifications cover four classes of bronze bearing metals for turntables and movable railroad bridges.

(*b*) The purposes for which these classes are frequently used are as follows:

Class A, for contact with hardened steel disks under pressures over 1500 lb. per sq. in., for example, bearing metals, used in turntables and center-bearing swing bridges;

Class B, for contact with soft steel at low speeds under pressures not over 1500 lb. per sq. in., for example, trunnions and journals of bascule and lift bridges;

Class C, for ordinary machinery bearings;

Class D, for gears, worm wheels, nuts and similar parts which are subjected to other than compressive stresses.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

I. MANUFACTURE.

Process. 2. (*a*) The bronze shall be a homogeneous alloy of copper and tin. The copper shall conform to the requirements of the Standard Specifications for Electrolytic Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars (Serial Designation: B 5), or the Standard Specifications for Lake Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars, "high-resistance" grade (Serial Designation: B 4), of the American Society for Testing Materials.[1] The bronze shall be made from new metal, except that scrap of known composition produced by the foundry at which the bronze is cast may be used.

(*b*) Care shall be exercised that the metal is not overheated and that the temperature at pouring and the conditions of cooling are such as will be most likely to secure dense castings.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition. 3. The bronze shall conform to the following requirements as to chemical composition:

Elements Considered.	Class.			
	A	B	C	D
Copper, per cent	Remainder	Remainder	not over 82	not over 89
Tin, max., per cent	20	17	11	11
Lead, max., per cent	....	....	11	....
Zinc, max., per cent	....	....	....	2.25
Iron, max., per cent	....	....	....	0.2
Phosphorus, per cent	not over 1.0	not over 1.0	0.7 - 1.0	not over 0.25
Other elements, max., per cent	0.5	0.5	0.5	0.5

Chemical Analyses. 4. (*a*) An analysis of each melt may be made at the option of the purchaser and at the purchaser's expense. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.[2]

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[1] 1918 Book of A.S.T.M. Standards.

[2] Material with a range of composition differing from that specified in Section 3, or containing elements not specified, may be used, provided the manufacturer shall submit in writing previous to the execution of the contract the range of composition of the material he proposes to use, and provided this range of composition shall be accepted by the purchaser.

(*b*) The compression test coupon shall be used for analysis.

III. PHYSICAL PROPERTIES AND TESTS.

Compression and Tension Tests.

5. (*a*) The bronze shall conform to the following requirements as to compressive and tensile properties:

Properties Considered.	Class.			
	A	B	C	D
Compression.				
Deformation limit, min., lb. per sq. in.	24 000	18 000	....	....
Permanent set in 1 in. under 100 000 lb. per sq. in., in.	0.06 – 0.12	0.10 – 0.20	....	....
Tension.				
Yield point, min., lb. per sq. in.	....	....	....	To be recorded
Tensile strength, min., lb. per sq. in.	....	....	....	33 000
Elongation in 2 in., min., per cent	....	....	....	14

(*b*) The deformation limit in compression shall be determined as that load which produces a permanent set of 0.001 in. in the compression test specimen described in Section 6 (*b*).

(*c*) The yield point in tension shall be determined as the stress producing an elongation under load of 0.5 per cent, that is, 0.01 in. in a gage length of 2 in.

Test Specimens.

6. (*a*) A test bar of the form and dimensions shown in Fig. 1, to be used for the tension test specimen, and a suitable test bar for the compression test specimen, shall be an integral part of the casting, and shall be fed and cooled under the same conditions as the castings.

(*b*) Compression test specimens shall be cylinders 1 sq. in. in cross-sectional area and 1 in. high.

(*c*) Tension test specimens, turned from the test bar shown in Fig. 1, shall conform to the dimensions shown in Fig. 2. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

Number of Tests.

7. (*a*) One compression test shall be made from each melt for Class A and B castings; and one tension test from each melt for Class D castings. For castings of any grade weighing over 100 lb. finished, the specified tests shall be made for each casting.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded; in which case the manufacturer and the purchaser or his representative shall agree upon the selection of another specimen in its stead.

IV. FINISH.

Finish. 8. The castings shall be sound, clean, and free from blowholes, porous places, cracks and other defects.

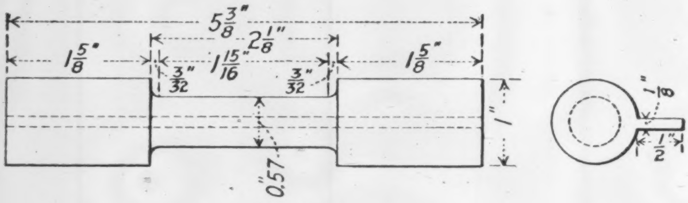
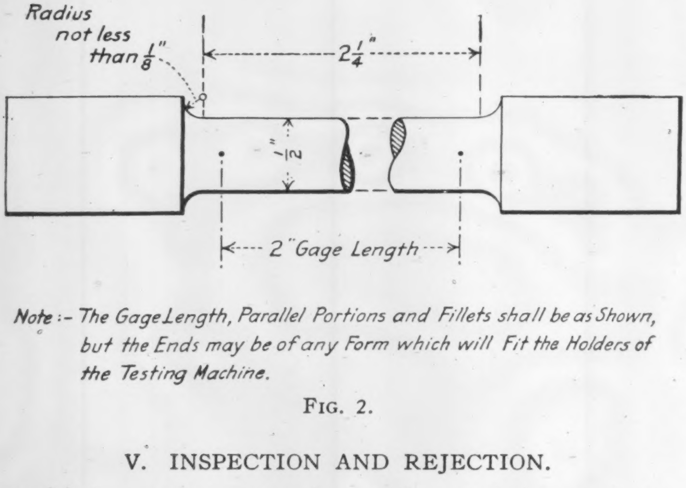


FIG. 1.



Note:- The Gage Length, Parallel Portions and Fillets shall be as Shown, but the Ends may be of any Form which will Fit the Holders of the Testing Machine.

FIG. 2.

V. INSPECTION AND REJECTION.

Inspection. 9. (*a*) Inspection may be made at the manufacturer's works where the castings are made, or at the point at which they are received, at the option of the purchaser.

(*b*) If the purchaser elects to have inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection.

10. Castings which show injurious defects revealed by machining operations subsequent to acceptance may be rejected, and if rejected, shall be replaced by the manufacturer free of cost to the purchaser. The full weight of the original material rejected shall be returned to the manufacturer.

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TENTATIVE SPECIFICATIONS
FOR
WHITE METAL BEARING ALLOYS (KNOWN COMMERCIALLY AS "BABBITT METAL").[1]

Serial Designation: B 23 – 18 T.

These specifications are issued under the fixed designation B 23; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1918.

Material Covered. 1. These specifications cover white metal bearing alloys, known commercially as "babbitt metal." Twelve typical babbitt metals are specified, covering the range of alloys commercially used and are designated as Grades Nos. 1 to 12, in accordance with their decreasing tin content as specified in Section 4.

I. MANUFACTURE.

Uniform Quality. 2. The manufacturer shall use care to have each lot of babbitt metal as uniform in quality as possible.

Dimensions. 3. The standard bar, unless otherwise specified, shall have the following approximate dimensions:

Top face	1¼ in. wide, 8½ in. long.
Thickness	not over 1¼ in.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition.

4. The alloys shall conform to the following requirements as to chemical composition, within the limits specified in Section 5:

Alloy, Grade No.	Tin, per cent.	Antimony, per cent.	Lead, per cent.	Copper, per cent.	Iron, max., per cent.	Arsenic, max., per cent.	Zinc, per cent.	Aluminum, per cent.
1........	91	4½	0.35[a]	4½	0.08	0.10	none	none
2........	89	7½	0.35[a]	3½	0.08	0.10	none	none
3........	83⅓	8⅓	0.35[a]	8⅓	0.08	0.10	none	none
4........	75	12	10	3	0.08	0.15	none	none
5........	65	15	18	2	0.08	0.15	none	none
6........	20	15	63½	1½	0.08	0.15	none	none
7........	10	15	75	0.50[a]	....	0.20	none	none
8........	5	15	80	0.50[a]	....	0.20	none	none
9........	5	10	85	0.50[a]	....	0.20	none	none
10........	2	15	83	0.50[a]	....	0.20	none	none
11........	..	15	85	0.50[a]	....	0.25	none	none
12........	..	10	90	0.50[a]	....	0.25	none	none

[a] Maximum.

Permissible Variations.

5. The following permissible variations in the percentages of the desired elements specified in Section 4 will be allowed, but shall not apply to the maximum percentages of impurities specified:

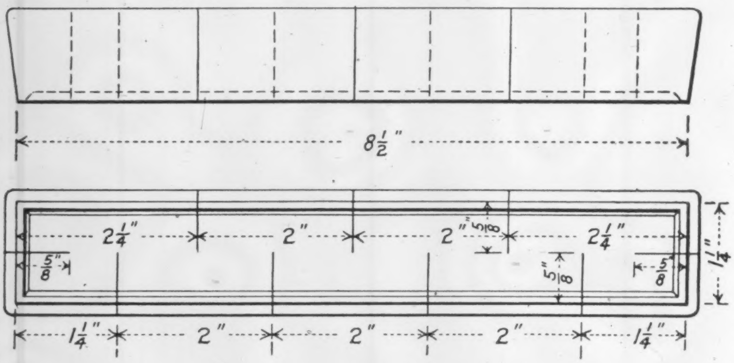
PERCENTAGE OF ELEMENT SPECIFIED.	PERMISSIBLE VARIATIONS OVER OR UNDER THE SPECIFIED VALUE, UNITS OF PER CENT.
Not over 2 per cent................................	0.25
Over 2 to 5 per cent, incl...........................	0.50
Over 5 to 10 per cent, incl..........................	0.75
Over 10 per cent...................................	1.00

Samples for Chemical Analysis.

6. (*a*) Three bars shall be selected to represent a shipment of less than 1000 lb., five bars to represent a shipment of over 1000 lb. to 10,000 lb., inclusive, and ten bars to represent a shipment of over 10,000 lb. to one carload.

(*b*) Saw cuts shall be made at points in the bars indicated in Fig. 1. No lubricants shall be used for sawing. The sawings shall be carefully treated with a magnet to remove any particles of steel introduced in taking the sample.

(*c*) Sawings thoroughly mixed shall constitute the sample for chemical analysis.


8½"
2¼"
2"
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2¼"
5/8"
5/8"
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5/8
1¼"
1¼"
2"
2"
2"
1¼"

FIG. 1.—Method of Sampling.

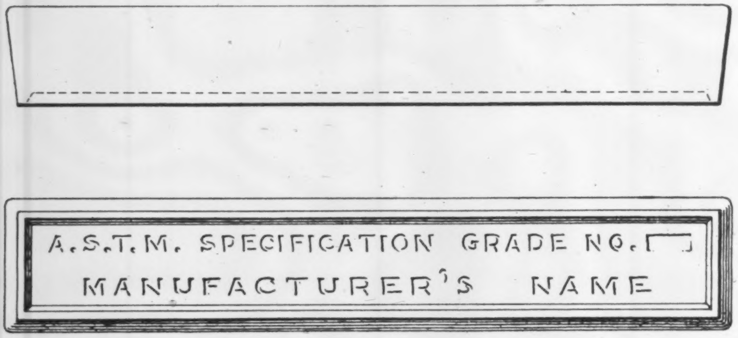
A.S.T.M. SPECIFICATION GRADE NO.
MANUFACTURER'S NAME

FIG. 2.—Preferred Arrangement of Marking.

Methods of Chemical Analysis.

7. The chemical analysis shall be made in accordance with the Tentative Methods for Chemical Analysis of Alloys of Lead, Tin, Antimony and Copper (Serial Designation: B 18–17 T) of the American Society for Testing Materials.[1]

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[1] See p. 509.

III. MARKING.

Marking. 8. The name of the manufacturer shall be cast on each bar. The numerical designation of the grade supplied shall be stamped or cast on each bar for identification.

(NOTE.—A preferred arrangement of marking is shown in Fig. 2.)

IV. CLAIMS.

Claims. 9. Claims, to be considered, shall be made in writing within thirty days of receipt of material at the purchaser's plant, and the results of the purchaser's tests shall be given. The shipper shall within one week of receipt of such claim, either agree to satisfy the claim or send a representative to the purchaser's plant to resample the shipment, as specified in Section 6. Samples so taken shall be sealed and submitted to a mutually agreeable umpire, whose determination shall be final.

Settlement of Claims. 10. The expense of umpire analysis shall be paid by the loser, or divided in proportion to the concession made in case of a compromise. In case of rejection being established, the damages shall be limited to the payment of freight both ways by the manufacturer for the substitution of an equivalent weight of babbitt metal meeting these specifications.

APPENDIX.

The data in the following table do not constitute a part of these specifications. They are given merely to indicate to the purchaser the physical properties of the various alloys specified which can be expected of carefully manufactured alloys of the formulas indicated, and to constitute a guide to the purchaser in selecting the grade best suited for meeting the service condition for which the babbitt metal is to be used. These figures are subject to revision.

TABLE SHOWING PHYSICAL PROPERTIES OF WHITE METAL BEARING ALLOYS.

Alloy No.	Formula.				Deformation of Cylinder $1\frac{1}{4}$ in. Diam. by $2\frac{1}{2}$ in. High at 70° F., in.			Brinell Hardness.		Melting Point.		Complete Liquation Point.		Specific Gravity.	Weight.		Proper Pouring Temperature, deg. Fahr.
	Copper, per cent.	Tin, per cent.	Antimony, per cent.	Lead, per cent.	At 1000 lb.	At 5000 lb.	At 10 000 lb.	At 70° F.	At 212° F.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.	Deg. Cent.		Oz. per cu. in.	Grams per cu. in.	
1....	4.5	91.0	4.5	....	0.000	0.001	0.015	28.6	12.8	437.0	225	699.8	371	7.34	4.24	120.28	824
2....	3.5	89.0	7.5	....	0.0000	0.0015	0.0120	28.3	12.7	460.4	238	683.6	362	7.39	4.27	121.10	808
3....	$8\frac{1}{3}$	$83\frac{1}{3}$	$8\frac{1}{3}$	....	0.0010	0.0045	0.0070	34.4	15.7	462.2	239	791.6	422	7.46	4.31	122.25	916
4....	3.0	75.0	12.0	10.0	0.0005	0.0025	0.0090	29.6	12.8	365.0	185	555.8	291	7.52	4.35	123.23	680
5....	2.0	65.0	15.0	18.0	0.0010	0.0030	0.0090	29.6	11.8	365.0	185	536.0	280	7.75	4.48	127.00	661
6....	1.5	20.0	15.0	63.5	0.0015	0.0050	0.0180	24.3	11.1	365.0	185	512.6	267	9.33	5.39	152.89	638
7....	..	10.0	15.0	75.0	0.0010	0.0050	0.0230	24.1	11.7	464.0	240	500.0	260	9.73	5.62	159.44	625
8....	..	5.0	15.0	80.0	0.0020	0.0090	0.0620	20.9	10.3	469.4	243	500.0	260	10.04	5.80	164.52	625
9....	..	5.0	10.0	85.0	0.0040	0.0120	0.0840	19.5	8.6	469.4	243	491.0	255	10.24	5.92	167.80	616
10....	..	2.0	15.0	83.0	0.0010	0.0100	0.1540	17.0	8.9	473.2	245	500.0	260	10.07	5.82	165.02	625
11....	..	..	15.0	85.0	0.0010	0.0100	0.1190	17.0	9.9	476.8	247	500.0	260	10.28	5.94	168.46	625
12....	..	..	10.0	90.0	0.0025	0.0170	0.2850	14.3	6.4	476.8	247	509.0	265	10.67	6.17	174.85	634

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TENTATIVE SPECIFICATIONS FOR ALUMINUM INGOTS FOR REMELTING AND FOR ROLLING.[1]

Serial Designation: B 24 – 19 T.

These specifications are issued under the fixed designation B 24; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1918; REVISED, 1919.

Material Covered.

1. These specifications cover two grades of aluminum, as follows:

Grade A, containing not less than 99.0 per cent aluminum.
Grade B, containing not less than 98.0 per cent aluminum.

I. SAMPLING.

Sampling.

2. One ingot of each heat shall be taken for analysis, and in any case not less than one sample ingot from each 500 lb. (226.8 kg.) of metal.

Samples shall be obtained by drilling completely through the ingot or half through from top to bottom. The weight of the samples obtained by drilling the ingot or ingots should not be less than 30 g.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

II. PHYSICAL DEFECTS.

Physical Defects.

3. Ingots for rolling shall be substantially free from shrink holes, cold sets, pits and similar defects in set or casting. Such defects are of no consequence in ingots which are to be remelted.

III. CLAIMS.

Claims.

4. (*a*) Claims, to be considered, shall be made in writing within thirty days of receipt of aluminum at the purchaser's plant, and the results of the purchaser's tests shall be given. The vendor shall be given one week from date of receipt of such claim to investigate his records, and shall then either agree to replace the defective aluminum or send a representative to the plant. No claims shall be considered unless made as above stated, and if the aluminum in question, unused, cannot be shown to the vendor's representative.

(*b*) In a question of metal contents each party shall select a sample of two pieces. These shall be drilled in the presence of both parties, several holes approximately ½ in. in diameter being drilled completely through each piece; scale from set shall not be rejected. No lubricant shall be used and drilling shall not be forced sufficiently to cause oxidation of chips. The resulting samples shall be cut up, mixed, and separated into three parts, each of which shall be placed in a sealed package, one for each party and one for the umpire if necessary. Each party shall make an analysis, and if the results do not establish or dismiss the claim to the satisfaction of both parties the third sample shall be submitted to a mutually agreeable umpire, who shall determine the question of fact, and whose determination shall be final.

Settlement of Claims.

5. The expense of the shipper's representative and of the umpire shall be paid by the loser, or divided in proportion to the concession made in case of compromise. In case of rejection being established, the damages shall be limited to payment of freight both ways by the vendor for the substitution of an equivalent weight of aluminum meeting these specifications.

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TENTATIVE SPECIFICATIONS
FOR
ALUMINUM SHEET.[1]

Serial Designation: B 25 – 19 T.

These specifications are issued under the fixed designation B 25; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1918; REVISED, 1919.

I. MANUFACTURE.

Manufacture.

1. No scrap shall be used in the manufacture of aluminum sheet except such as shall accumulate at the manufacturer's own plant from material of the same composition and of his own manufacture.

II. CHEMICAL PROPERTIES AND TESTS.

2. The sheet may be rolled from aluminum ingots of Grade A, described in the Tentative Specifications for Aluminum Ingots for Remelting and for Rolling (Serial Designation: B 24–18 T) of the American Society for Testing Materials.[2]

Chemical Analysis.

3. Samples for analysis shall be obtained from a random sheet, representing each 500 lb. (226.8 kg.) of aluminum or any lot weighing less than 500 lb. (226.8 kg.), as agreed upon between

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

[2] See p. 473.

the seller and the purchaser. Samples so prepared shall be divided into three equal parts, each of which shall be placed in a sealed package, one for each party and one for an umpire if necessary. The sample for analysis may be prepared by shearing.

III. PHYSICAL PROPERTIES AND TESTS.

Tension Tests. 4. (*a*) Sheets may be furnished in either of three tempers or degrees of hardness and shall conform to the following requirements as to tensile properties:

TEMPER No. 1; SOFT, ANNEALED.

B. & S. Gage.	Thickness, in.	Minimum Tensile Strength, lb. per sq. in.	Minimum Elongation in 2 in., per cent.
12 to 16, incl.	0.0808 - 0.0509	12 500	30
17 " 22, "	0.0508 - 0.0227	12 500	20
23 " 26, "	0.0226 - 0.0159	12 500	10
TEMPER No. 2; HALF-HARD.			
12 to 16, incl.	0.0808 - 0.0509	18 000	7
17 " 22, "	0.0508 - 0.0227	18 000	5
23 " 26, "	0.0226 - 0.0159	18 000	5
TEMPER No. 3; HARD.			
12 to 16, incl.	0.0808 - 0.0509	22 000	4
17 " 22, "	0.0508 - 0.0227	25 000	2
23 " 26, "	0.0226 - 0.0159	30 000	2

(*b*) The tension test specimen shall be taken parallel to the direction of cold rolling of the sheet.

Bend Tests. 5. Sheets of temper No. 1 shall withstand being bent double in any direction and hammered flat, and sheets of temper No. 2, being bent around a pin of radius equal to the thickness of the sheet, without cracking.

Number of Tests. 6. (*a*) One tension and one bend test specimen shall be cut from a random sheet representing each 500 lb. (226.8 kg.) of aluminum or any lot weighing less than 500 lb. (226.8 kg.), as agreed upon between the seller and the purchaser.

(*b*) Test specimens may be used for purposes of analysis specified in Section 3.

IV. PERMISSIBLE VARIATIONS IN DIMENSIONS.

Dimensional Variations.

7. The thickness of sheets shall not vary from that specified by more than the following amounts:

B. & S. Gage.	Thickness, in.	Permissible Variation, in.
10 to 17, incl.	0.1019 - 0.0404	0.003
18 " 26, "	0.0403 - 0.0159	0.002

V. WORKMANSHIP AND FINISH.

Workmanship.

8. All sheets shall be commercially flat and free from buckles; they shall be free from injurious surface defects and shall have a workmanlike finish.

VI. INSPECTION AND REJECTION.

Inspection.

9. The manufacturer shall afford the inspector representing the purchaser, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection.

10. Material which fails to conform to these specifications will be rejected and the manufacturer shall be notified.

EXPLANATORY NOTES.

Section 4.—Aluminum sheet cut in other directions than parallel to the direction of cold rolling will show a ductility less than that in this direction; the elongation at right angles to the direction of cold rolling may be only two-thirds of the former.

It is strongly recommended that a self-centering tension test specimen holder be used for testing particularly thin gages of hard aluminum sheet, in view of the lack of uniformity which may occur in test series made in the usual wedge grips.

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TENTATIVE SPECIFICATIONS
FOR
LIGHT ALUMINUM CASTING ALLOYS.[1]

Serial Designation: B 26 – 19 T.

These specifications are issued under the fixed designation B 26; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1918; REVISED, 1919.

Material Covered. 1. These specifications cover commercial light alloys of aluminum having a specific gravity of 3 and less.

I. MANUFACTURE.

Process. 2. The alloy may be made by any approved method.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition. 3. The following alloys are described by these specifications; they shall conform to the following requirements as to chemical composition:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

Alloy.	Copper, per cent.	Zinc, per cent.	Manganese, per cent.	Maximum Total Impurities, per cent.	Aluminum, per cent.
A	7 – 8.5	......	......	1.7	Remainder
B	8.5 – 11	......	......	1.7	Remainder
C	11 – 14	......	......	1.7	Remainder
D	2.5 – 3.0	12.5 – 14.5	......	1.7[a]	Remainder
E	2 – 2.5	......	0.75 – 1.25	1.0	Remainder

[a] Lead content shall not be greater than 0.1 per cent.

Sampling.

4. (*a*) The sample for chemical analysis may be taken either by sawing, drilling or milling the casting or tension test specimen and shall represent the average cross-section of the piece.

(*b*) The saw, drill, cutter or other tool used shall be thoroughly cleaned. No lubricant shall be used in the operation, and the sawdust or metal chips shall be carefully treated with a magnet to remove any particles of iron introduced in taking the sample.

III. PHYSICAL PROPERTIES AND TESTS.

Tension Tests.

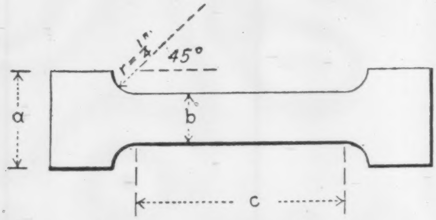
5. The alloys shall conform to the following minimum requirements as to tensile properties:

Alloy.	Minimum Tensile Strength, lb. per sq. in.	Minimum Elongation in 2 in., per cent.
A	18 000	1
B	18 000	..
C	19 000	..
D	25 000	1
E	18 000	8

Test Specimens.

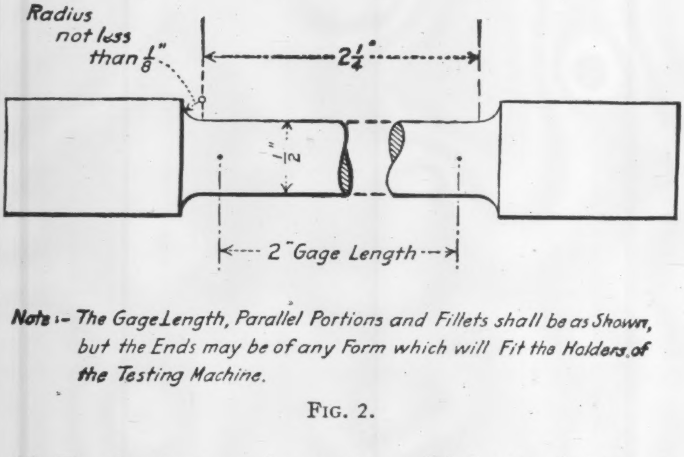
6. (*a*) Two test bars of the form and dimensions shown in Fig. 1 shall be an integral part of large castings, or cast separately in the case of small castings to represent a lot or melt, and shall be molded in a manner similar to the castings which they represent. If the castings are heat-treated, the test bars representing such castings shall be similarly heat-treated.

(*b*) The manufacturer and purchaser shall agree whether test bars can be attached to castings, on the location of the bars on the castings, on the castings to which bars are to be attached, and on the method of casting unattached bars.



a---- 1 in.
b --- not greater than $\frac{5}{8}$ in., nor less than $\frac{1}{2}$ in.
c --- not less than $2\frac{1}{8}$ in.

FIG. 1.



Note:– The Gage Length, Parallel Portions and Fillets shall be as Shown, but the Ends may be of any Form which will Fit the Holders of the Testing Machine.

FIG. 2.

(*c*) Tension test specimens, turned from the test bar shown in Fig. 1, shall conform to the dimensions shown in Fig. 2. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

Number of Tests.

7. (*a*) Tests shall as far as possible be made by heats or melts, but unless otherwise agreed, two tension tests shall be made upon each unit lot of 500 lb. or single delivery of less than 500 lb.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded; in which case the manufacturer and the purchaser or his representative shall agree upon the selection of another specimen in its stead.

IV. INSPECTION AND REJECTION.

Inspection.

8. (*a*) Inspection may be made at the manufacturer's works where the castings are made, or at the point at which they are received, at the option of the purchaser.

(*b*) If the purchaser elects to have inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection.

9. Castings which show injurious defects revealed by machining operations subsequent to acceptance may be rejected, and if rejected, shall be replaced by the manufacturer free of charge to the purchaser. The full weight of the original material rejected shall be returned to the manufacturer.

EXPLANATORY NOTES.

The alloys described may be divided into two groups: those (A, B, C, D) having a relatively high hardness, as evidenced by the proportional limit, but little or no ductility; and E, which has a relatively low proportional limit, but a fair ductility. Thus the alloys A and D are quite suitable for general castings which, although highly stressed in service, will not likely be subjected to overstress. If a casting is likely to be subjected to a very rough treatment tending to overstress it, a more ductile alloy, E, is to be preferred.

Alloys B and C are suitable for high temperature and pressure service. Alloy B is recommended for pistons, alloy C for manifolds, carburetors, pumps, etc. Average values for other physical properties of these alloys are given in the following table:

PHYSICAL PROPERTIES OF ALUMINUM ALLOYS.

Alloy.	Density, g. per cc.	Shrinkage, in. per ft.	Temperature, Melting Range.		Proportional Limit, lb. per sq. in.
			Deg. Cent.	Deg. Fahr.	
A	2.89	0.156	637 - 540	1146 - 972	about 10 000
B	2.95	0.156	630 - 540	1133 - 972	....
C	3.00	0.156	623 - 540	1120 - 972	....
D	3.00	0.156	625 - 440	1124 - 792	....
E	2.79	0.156	649 - 529	1166 - 952	less than 2 000

Section 5.—The elongations obtained with Alloys B, C and D are generally less than 1 per cent and are too small to be satisfactorily measured.

Section 6.—Some latitude has been allowed in the diameter of the cast test bars; test bars cast to size are stronger than those which are machined, and the tensile properties specified can be obtained under usual conditions only with the cast-to-size bar.

It is strongly recommended that a self-centering form of tension test specimen holder be used. Most aluminum alloys (A, B, C, D) are brittle and give lower and less uniform test results when tested in ordinary wedge grips without centering.

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TENTATIVE SPECIFICATIONS
FOR
LEAD.[1]

Serial Designation: B 29 – 19 T.

These specifications are issued under the fixed designation B 29; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

Definition. 1. Virgin Lead is lead made from ore or similar raw material by direct processes of reduction and refining, and not produced from reworked metal.

Grades. 2. Under these specifications Virgin Lead is considered in three grades, as follows:

I. Corroding Lead.
II. Chemical Lead.
III. Common Lead.

I. MANUFACTURE.

Uniform Quality. 3. The maker shall use care to have each carload of as uniform quality as possible.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

II. CHEMICAL PROPERTIES AND TESTS.

(*A*) *Chemical Composition.*

Corroding Lead. 4. Corroding Lead (Grade I) shall conform to the following requirements as to chemical composition:

Silver	not over	0.0015	per cent.
Copper	" "	0.001	"
Arsenic	" "	0.001	"
Antimony and Tin together	" "	0.0075	"
Zinc	" "	0.001	"
Iron	" "	0.0015	"
Bismuth	" "	0.05	"
Lead (by difference)		99.9365	"

Chemical Lead. 5. Chemical Lead (Grade II) shall conform to the following requirements as to chemical composition:

Copper		0.05 – 0.10	per cent.
Bismuth	not over	0.005	"
Total Impurities other than Copper	" "	0.05	"

Common Lead. 6. Common Lead (Grade III) shall conform to the following requirements as to chemical composition:

(*a*) *Desilverized Lead:*

Silver	not over	0.002	per cent.
Copper	" "	0.0025	"
Arsenic, Antimony and Tin together	" "	0.015	"
Bismuth	" "	0.35	"
Iron	" "	0.002	"
Zinc	" "	0.002	"
Lead (by difference)		99.6265	"

(*b*) *Soft Missouri Lead:*[1]

Silver	not over	0.002	per cent.
Copper	" "	0.05	"
Arsenic, Antimony and Tin together	" "	0.015	"
Bismuth	" "	0.005	"
Iron	" "	0.005	"
Zinc	" "	0.002	"
Lead (by difference)		99.921	"

(*B*) *Sampling and Analysis.*

Sampling. 7. (*a*) In sampling, a carload or less shall be considered a lot or unit. One pig shall be taken to represent each ton of

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[1] Soft Missouri Lead is a trade name used to cover soft undesilverized lead in general.

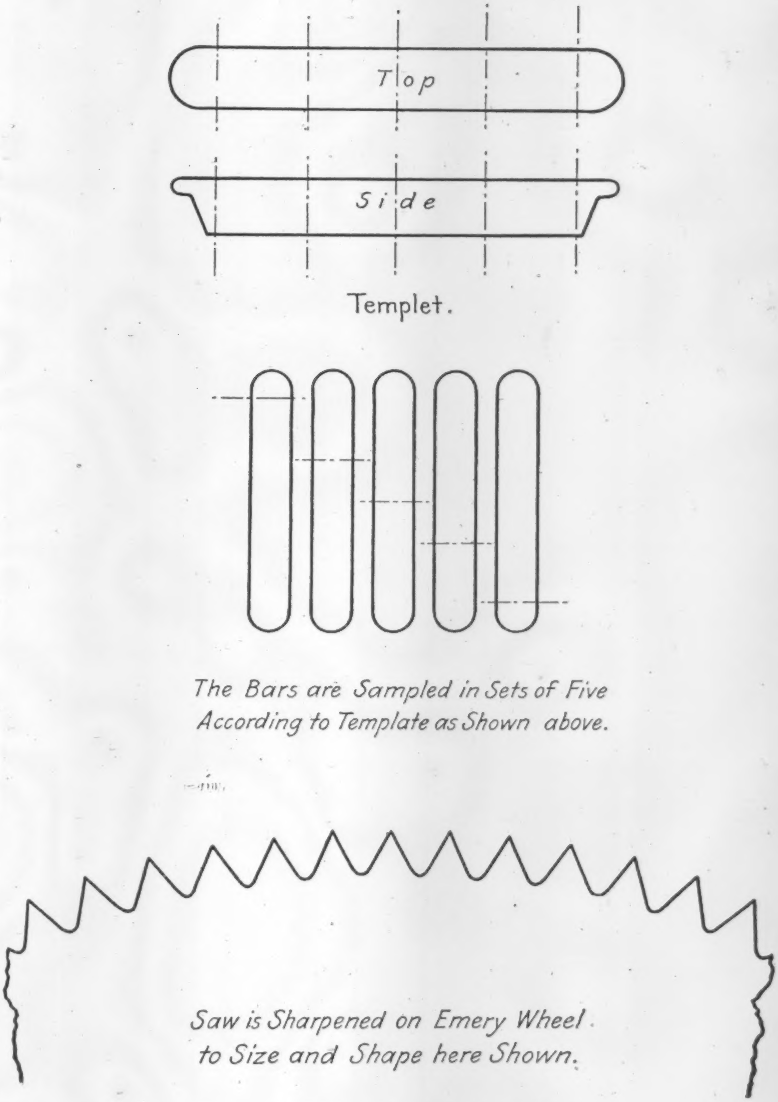
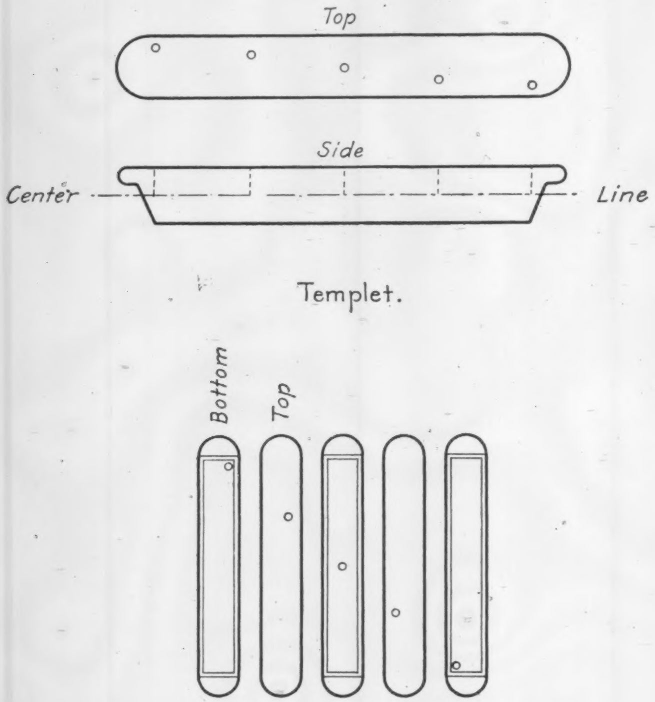

Top
Side
Templet.
The Bars are Sampled in Sets of Five
According to Template as Shown above.
Saw is Sharpened on Emery Wheel
to Size and Shape here Shown.

FIG. 1.—Saw Method of Sampling Lead.

lead in the lot. The pigs thus taken shall be sampled by one of the following methods:

1. By sawing completely through, as illustrated in Fig. 1;



The Bars Selected as Samples are Placed in a Line with every other Bar, Bottom Side up. The Sampling is Done according to Template in Sets of five Bars each, as Indicated above. The Punch must be Driven Halfway through the Bar. In Case a Larger Sample is Desired, the Bars are Turned over and Sampled on the other Diagonal.

FIG. 2.—Punch Method of Sampling Lead.

2. By punching completely through (if equipment permits) or punching half-way through from two opposite sides, as illustrated in Figs. 2 and 3;
3. By drilling at least half-way through.

(*b*) Whenever the surface of the pigs to be sampled is dirty, care shall be taken to see that none of the dirt or foreign material gets into the sample.

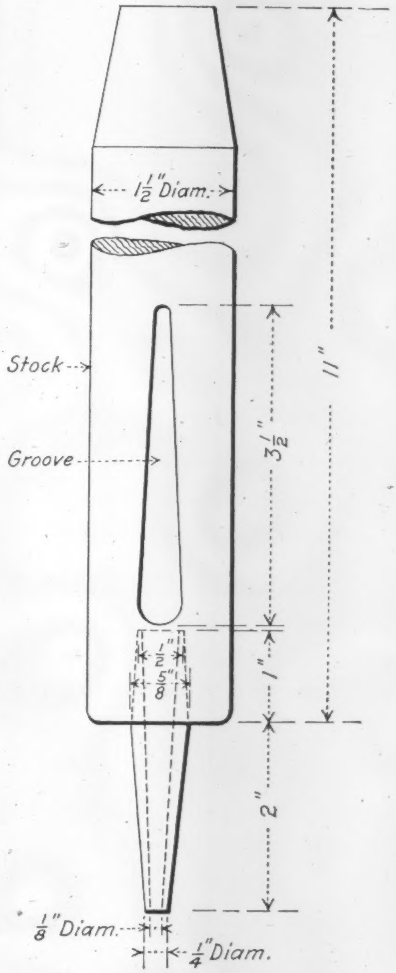


FIG. 3.—Sample Punch for Lead.

8. If the sample is taken by sawing, the sawdust from all the pigs shall be thoroughly mixed and quartered and the sample for analysis drawn from the mixed material. Care shall be taken that the sawdust is free from all extraneous material. **Sawing.**

Punching or Drilling.

9. If the sample is taken by punching or drilling, the holes shall be spaced along a diagonal line from one corner of the pig to the other. Sampling in this manner may be so arranged that one or more holes are made in each of several pigs of a group in such positions that they represent consecutive positions on the diagonal of a single pig. (See illustration in Fig. 2.)

(*a*) If punchings are taken, they may be carefully melted in a clean graphite crucible, and either granulated by carefully pouring into distilled water and thoroughly drying, or casting into thin slabs which shall be sawed completely through in several places and the sawdust treated as described in Section 8.

(*b*) If drillings are taken, they may be clipped and mixed, and the sample for analysis drawn from the mixed material; or they may be melted as in the case of punchings.

Methods of Chemical Analysis.

10. The chemical analysis shall be made in accordance with the Tentative Methods for Chemical Analysis of Pig Lead (Serial Designation: B 35 – 19 T) of the American Society for Testing Materials.[1]

III. MARKING.

Marking.

11. A brand shall be cast or otherwise plainly marked upon each pig by which the maker and grade may be identified.

IV. CLAIMS.

Claims.

12. (*a*) Claims, to be considered, shall be made in writing within 30 days of receipt of the material at the purchaser's plant, and the results of the purchaser's tests shall be given. The seller shall be given one week from date of receipt of such claim to investigate his records, and then shall agree either to satisfy the claim or to the submission of samples to an umpire. No claim shall be considered unless the sample pigs can be shown to the seller's representative.

(*b*) Where the lead satisfies the purity requirements of these specifications, it shall not be condemned for defects in the products in which it is used.

Investigation of Claims.

13. On questions of purity a sample shall be drawn by representatives of both parties, as described under "Sampling." The properly mixed and quartered sample shall be separated into

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[1] See p. 523.

three parts, each of which shall be placed in a sealed package, one for each party and one for an umpire, if necessary. Each party shall make an analysis, and if the results do not establish or dismiss the claim to the satisfaction of both parties, the third sample shall be submitted to a mutually agreeable umpire, who shall determine the question of quality, and whose determination shall be final.

Settlement of Claims.

14. The expense of the seller's representative and of the umpire shall be paid by the loser, or divided in proportion to the concession made in case of compromise. In case of rejection being established, damages shall be limited to the payment of freight both ways by the seller for substitution of an equivalent weight of lead meeting these specifications.

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TENTATIVE SPECIFICATIONS
FOR
BRASS INGOT METAL FOR SAND CASTINGS.[1]

Serial Designation: B 30 – 19 T.

These specifications are issued under the fixed designation B 30; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

Material Covered. 1. These specifications cover brass ingot metal for sand castings, known commercially as red and yellow brass ingot, made wholly or partly from scrap materials. Seven typical alloys are specified and are designated Grades Nos. 1 to 7, in accordance with their decreasing copper content as specified in Section 3.

I. MANUFACTURE.

Uniform Quality. 2. The manufacturer shall use care to have each lot of ingot metal as uniform in quality as possible.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition. 3. The alloys shall conform to the following requirements as to chemical composition, within the limits specified in Section 4:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

Alloy, Grade No.	Copper, per cent.	Tin, per cent.	Lead, per cent.	Zinc, per cent.	Iron, max., per cent.	Antimony, max., per cent.	Aluminum, per cent.	Sulfur, max., per cent.
1	86	8	3[a]	3	0.25	0.25	none	0.05
2	85	5	5	5	0.35	0.25	none	0.05
3	83	4	6	7	0.35	0.25	none	0.05
4	77	3	10	10	0.40	0.35	none	0.05
5	76	2	6	16	0.40	0.25	none	0.05
6	65	1[a]	2	33	0.50	0.20	none[1]	0.05
7	60	1½[a]	3	37	1.00	0.20	none[1]	0.05

[a] Maximum. [1] See Appendix.

Permissible Variations. 4. The following permissible variations in the percentages of the desired elements specified in Section 3 will be allowed, but shall not apply to the maximum percentages of impurities specified:

PERCENTAGE OF ELEMENT SPECIFIED.	PERMISSIBLE VARIATIONS OVER AND UNDER THE SPECIFIED VALUE, UNITS OF PER CENT.
Not over 5 per cent	0.50
Over 5 to 10 per cent, incl	0.75
Over 10 per cent	1.00

Samples for Chemical Analysis. 5. (*a*) Three ingots shall be selected by the inspector to represent 10,000 lb. of ingot or fraction thereof.

(*b*) The samples for chemical analysis may be taken either by sawing, drilling or milling the ingots and shall represent the average cross-section.

(*c*) The saw, drill, cutter or other tool used shall be thoroughly cleaned. No lubricant shall be used in the operation, and the sawings or metal chips shall be carefully treated with a magnet to remove any particles of steel introduced in taking the sample.

Methods of Chemical Analysis. 6. To be prepared by the Committee.

III. MARKING.

Marking. 7. The designating mark of the manufacturer, the proper lot number, and the numerical designation of the grade supplied shall be marked on each ingot for identification.

IV. INSPECTION AND REJECTION.

Inspection. 8. (*a*) Inspection may be made at the manufacturer's works where the ingots are made, or at the point at which they are received, at the option of the purchaser.

(*b*) If the purchaser elects to have inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 9. If the test ingots selected to represent a lot fail to conform to the requirements specified in Sections 3 and 4, all ingots in such lot will be rejected.

V. CLAIMS.

Claims. 10. Claims, to be considered, shall be made in writing within thirty days of receipt of material at the purchaser's plant, and the results of the purchaser's tests shall be given. The shipper shall within one week of receipt of such claim, either agree to satisfy the claim or send a representative to the purchaser's plant to resample the shipment, as specified in Section 5. Samples so taken shall be sealed and submitted to a mutually agreeable umpire, whose determination shall be final.

Settlement of Claims. 11. The expense of umpire analysis shall be paid by the loser or divided in proportion to the concession made in case of a compromise. In case of rejection being established, the damages shall be limited to the payment of freight both ways by the manufacturer for the substitution of an equivalent weight of ingot metal meeting these specifications.

APPENDIX.

The data in the following table do not constitute a part of these specifications. They are given merely to indicate to the purchaser the physical properties of the various alloys specified which can be expected of carefully manufactured alloys of the formulas indicated, and to constitute a guide to the purchaser in selecting the grade best suited for meeting the service condition for which the ingot metal is to be used.

TABLE SHOWING PHYSICAL PROPERTIES OF BRASS INGOT METAL ALLOYS.

Alloy, Grade No.	DESIRED COMPOSITION.				Tensile Strength, lb. per sq. in.[1]	Elongation, in 2 in., per cent.[1]	Reduction of Area, per cent.[1]	Brinell Hardness (500 kg. for 30 sec.).	Shrinkage, in. per ft.	Weight, lb. per cu. in.
	Copper, per cent.	Tin, per cent.	Lead, per cent.	Zinc, per cent.						
1	86	8	3	3	30-36 000	25-30	25-30	.....	0.125	0.31
2	85	5	5	5	27-33 000	16-20	15-20	50-60	0.14	0.31
3	83	4	6	7	28-33 000	15-20	20-26	55-60	0.125	0.31
4	77	3	10	10	23-28 000	10-15	10-15	50-55	0.125	0.32
5	76	2	6	16	25-30 000	20-30	20-30	43-48	0.18	0.31
6	65	...	2	33	25-30 000	20-30	25-35	37-42	0.18	0.30
7	60	...	3	37	30-45 000	15-25	20-30	43-48	0.20	0.29

[1] The tension tests were made on "sand cast-to-size" test specimens.

Grade No.	Example of Uses.	Foundry Manipulation.	Characteristics.
1	High grade steam metal	Easily handled	Machines well.
2	High grade red brass for general service	Easily handled	Machines more readily than No 1.
3	Medium grade red brass for general service	Easily handled	Machines more readily than No. 1.
4	Small valves and fittings	Not difficult	Machines very easily.
5	Reddish yellow alloy, for air, gas and water fittings.	Not difficult	Machines very easily.
6	Yellow brass for general service	Difficult. Aluminum up to 0.3 per cent improves casting properties, but increases shrinkage.	Machines poorly. Not suitable for bearings or water pressure fittings.
7	Plumbers' flanges, scupper pipes, etc	Very difficult. Aluminum up to 0.3 per cent improves casting properties, but increases shrinkage.	Hard to machine. Not suitable for bearings or water pressure fittings.

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TENTATIVE SPECIFICATIONS
FOR
BRONZE BEARING METAL IN INGOT FORM.[1]

Serial Designation: B 31 – 19 T.

These specifications are issued under the fixed designation B 31; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

Material Covered.

1. These specifications cover copper- tin- lead alloys in ingot form, known commercially as "bronze bearing metal," made wholly or partly from scrap materials. Six typical alloys are specified and are designated as Grades Nos. 1 to 6, in accordance with their decreasing copper content as specified in Section 3.

I. MANUFACTURE.

Uniform Quality.

2. The manufacturer shall use care to have each lot of bronze bearing metal as uniform in quality as possible.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition.

3. The alloys shall conform to the following requirements as to chemical composition, within the limits specified in Section 4:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

Alloy, Grade No.	Copper, per cent.	Tin, per cent.	Lead, per cent.	Zinc, max., per cent.	Phosphorus, per cent.	Sulfur, max., per cent.	Iron, max., per cent.	Antimony, max., per cent.	Aluminum, per cent.	Total Impurities, max., per cent.
1.......	85	10	5	0.25	0.70[a]	0.05	0.25	0.50	none	0.50
2.......	80	10	10	0.50	0.70[a]	0.05	0.25	0.50	none	0.75
3.......	80	10	10	2.00	0.05[b]	0.05	0.25	0.50	none	2.50
4.......	77	8	15	0.50	0.25[b]	0.05	0.25	0.50	none	0.75
5.......	73	7	20	0.50	0.05[b]	0.25	0.25	0.50	none	1.00
6.......	70	5	25	0.50	none	0.25	0.25	0.50	none	1.00

[a] Minimum. [b] Maximum.

Permissible Variations.

4. The following permissible variations in the percentages of the desired elements specified in Section 3 will be allowed, but shall not apply to the maximum percentages of impurities specified:

PERCENTAGE OF ELEMENT SPECIFIED.	PERMISSIBLE VARIATIONS OVER AND UNDER THE SPECIFIED VALUE, UNITS OF PER CENT.
Not over 5 per cent	0.50
Over 5 to 10 per cent, incl	0.75
Over 10 per cent	1.50

Samples for Chemical Analysis.

5 (*a*). Three ingots shall be selected by the inspector to represent 10,000 lb. of ingot or fraction thereof.

(*b*) The samples for chemical analysis may be taken either by sawing, drilling or milling the ingots and shall represent the average cross-section.

(*c*) The saw, drill, cutter or other tool used shall be thoroughly cleaned. No lubricant shall be used in the operation, and the sawings or metal chips shall be carefully treated with a magnet to remove any particles of steel introduced in taking the sample.

Methods of Chemical Analysis.

6. To be prepared by the Committee.

III. MARKING.

Marking.

7. The designating mark of the manufacturer, the proper lot number, and the numerical designation of the grade supplied shall be marked on each ingot for identification.

IV. INSPECTION AND REJECTION.

Inspection.

8. (*a*) Inspection may be made at the manufacturer's works where the ingots are made, or at the point at which they are received, at the option of the purchaser.

(*b*) If the purchaser elects to have inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection.

9. If the test ingots selected to represent a lot fail to conform to the requirements specified in Sections 3 and 4, all ingots in such lot will be rejected.

V. CLAIMS.

Claims.

10. Claims, to be considered, shall be made in writing within thirty days of receipt of material at the purchaser's plant, and the results of the purchaser's tests shall be given. The shipper shall within one week of receipt of such claim, either agree to satisfy the claim or send a representative to the purchaser's plant to resample the shipment, as specified in Section 5. Samples so taken shall be sealed and submitted to a mutually agreeable umpire, whose determination shall be final.

Settlement of Claims.

11. The expense of umpire analysis shall be paid by the loser or divided in proportion to the concession made in case of a compromise. In case of rejection being established, the damages shall be limited to the payment of freight both ways by the manufacturer for the substitution of an equivalent weight of bronze bearing metal meeting these specifications.

APPENDIX.

The data in the following table do not constitute a part of these specifications. They are given merely to indicate to the purchaser the physical properties of the various alloys specified which can be expected of carefully manufactured alloys of the formulas indicated, and to constitute a guide to the purchaser in selecting the grade best suited for meeting the service condition for which the bronze bearing metal is to be used.

TABLE SHOWING PHYSICAL PROPERTIES OF BRONZE BEARING METAL ALLOYS.

Alloy, Grade No.	DESIRED COMPOSITION.			Ultimate Tensile Strength, lb. per sq. in.[1]	Elongation, in 2 in., per cent.[1]	Brinell Hardness (500 kg. for 30 sec.)	Shrinkage, in. per ft.	Weight, lb. per cu. in.	Compression, Elastic Limit, lb. per sq. in.[2]
	Copper, per cent.	Tin, per cent.	Lead, per cent.						
1..........	85	10	5	28 000	12.5	60	0.25	0.31	18 000
2..........	80	10	10	25 000	8	55	0.25	0.31	15 000
3..........	80	10	10	22 000	8	50	0.25	0.32	12 500
4..........	77	8	15	20 000	10	48	0.25	0.33	12 000
5[a].........	73	7	20	18 000	7	45	0.25	0.33	11 000
6[a].........	70	5	25	15 000	5	40	0.25	0.33	10 000

[a] More difficult to handle in the foundry than the other grades on account of the segregation of lead. Can be improved by the addition of 1 per cent of nickel.

[1] The tension tests were made on "sand cast-to-size" test specimens.

[2] The compression tests were made on machined test specimens (sand castings) of 1 sq. in. sectional area, 1 in. high. The elastic limit is taken as the load producing a compression in the specimen of 0.001 in.

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TENTATIVE SPECIFICATIONS
FOR
SOLDER METAL.[1]

Serial Designation: B 32 – 19 T.

These specifications are issued under the fixed designation B 32; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

Material Covered.

1. (*a*) These specifications cover lead-tin alloys used for solder metal and commercially known as soft solder.

(*b*) Two classes, A and B, are given, in each of which several compositions are specified covering the range of alloys commercially used and designated as Grades Nos. 0 to 5, in accordance with their decreasing tin content as specified in Section 4.

The choice of the class and grade of solder for any specified purpose depends on the material in connection with which it is to be used and the method of applying. For galvanized iron and zinc, only Class A should be used. Recommended practice is given in an appendix to these specifications, together with a table showing melting points to constitute a guide to the purchaser in selecting the grade best suited for meeting the conditions required.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably, before January 1, 1920, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

I. MANUFACTURE.

Uniform Quality.

2. The manufacturer shall use care to have each lot of solder metal as uniform in quality as possible. Each bar, ingot, or other form in which the solder is sold shall be uniform in composition with the entire lot. All grades in Class A shall be made from new or virgin metals. All grades in Class B shall be made from at least one-half new or virgin metals, the balance being recovered or secondary metals.

Dimensions.

3. When specified in bar or ingot form, the sizes or shapes, unless otherwise specified, shall be approximately as follows:

			LENGTH, IN.	WIDTH, IN.	THICKNESS, IN.
A	Bar	Top	13½	¾	⅜
		Bottom	13½	⅝	
B	Ingot	Top	5½	2½	1½
		Bottom	4½	1½	

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition.

4. The alloys shall conform to the following requirements as to chemical composition, within the limits specified in Section 5:

Grade No.	Tin, per cent.	Lead, Approx., per cent.	Antimony, max., per cent.	Copper, max., per cent.	Zinc and Aluminum, per cent.	Other Impurities,[1] max., per cent.
CLASS A.						
0	63.00	37.00	0.12	0.08	none	0.10
1	50.00	50.00	0.12	0.08	none	0.10
2	45.00	55.00	0.12	0.08	none	0.10
3	40.00	60.00	0.12	0.08	none	0.10
4	37.50	62.50	0.12	0.08	none	0.10
5	33.00	67.00	0.12	0.08	none	0.10
CLASS B.						
1	49.25	50.00	0.75	0.15	none	0.10
2	43.50	55.00	1.50	0.15	none	0.10
3	38.00	60.00	2.00	0.15	none	0.10
4	35.50	62.50	2.00	0.15	none	0.10
5	31.00	67.00	2.00	0.15	none	0.10

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[1] Exclusive of Bismuth.

Permissible Variations. 5. The permissible variation plus or minus in the percentage of tin shall not be over 1 per cent of the tin contents specified in Section 4.

Sample for Chemical Analysis. 6. (*a*) Three bars or ingots shall be selected to represent a shipment of less than 1000 lb., five bars or ingots to represent a shipment of over 1000 lb. to 10,000 lb., inclusive, and ten bars or ingots to represent a shipment of over 10,000 lb. to one carload. In case the shipment is in other form, such as wire, wire segments, drops, pigs or slabs, an equivalent amount of metal representative of the lot shall be taken, but in no case shall less than one whole piece (except wire) represent a shipment.

(*b*) The preferable method of preparing the sample for chemical analysis is to cut exactly in half the bars selected, marking each half and retaining one of each of the half bars to preserve their identity and for check analysis. The remaining half of each bar shall then be remelted in a perfectly clean utensil at a temperature a little above the complete liquation point of the alloy, mixed thoroughly and poured into a cold mold, forming a thin bar approximately $\frac{1}{4}$ in. thick. Saw cuts shall then be made entirely across this bar not more than 1 in. apart and evenly distributed throughout its length.

If it is impracticable to remelt the sample as above, saw cuts shall be made entirely across each piece at several points not more than 1 in. apart and evenly distributed throughout their length. No lubricants shall be used for sawing.

(*c*) Sawings thoroughly mixed shall constitute the sample for chemical analysis.

Methods of Chemical Analysis. 7. The chemical analysis shall be made in accordance with the Tentative Methods for Chemical Analysis of Alloys of Lead, Tin, Antimony and Copper (Serial Designation: B 18–17 T) of the American Society for Testing Materials.[1]

III. MARKING.

Marking. 8. The name of the manufacturer may be cast, at the option of the purchaser, on each bar or ingot. The numerical designation of the grade supplied shall be stamped or cast on each bar or ingot for identification.

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[1] See p. 509.

IV. INSPECTION AND REJECTION.

Inspection.

9. (*a*) Inspection may be made at the manufacturer's works where the solder metal is made, or at the point at which it is received, at the option of the purchaser.

(*b*) If the purchaser elects to have inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection.

10. If the sample selected to represent a lot fails to conform to the requirements specified in Sections 3 and 4, all solder metal in such lot will be rejected.

V. CLAIMS.

Claims.

11. Claims, to be considered, shall be made in writing within thirty days of receipt of material at the purchaser's plant, and the results of the purchaser's tests shall be given. The shipper shall within one week of receipt of such claim, either agree to satisfy the claim or send a representative to the purchaser's plant to resample the shipment, as specified in Section 6. Samples so taken shall be sealed and submitted to a mutually agreeable umpire, whose determination shall be final.

Settlement of Claims.

12. The expense of umpire analysis shall be paid by the loser, or divided in proportion to the concession made in case of a compromise. In case of rejection being established, the damages shall be limited to the payment of freight both ways by the manufacturer for the substitution of an equivalent weight of solder metal meeting these specifications.

APPENDIX.

It is recommended that the grade of solder metal be selected which contains the least amount of tin required to give suitable flowing and adhesive qualities for the work in hand.

A table is appended showing the melting points of the different grades of solder metal and of tin and lead for comparison. It is to be noted that the alloys are completely solid below the lower point given, designated "melting point", and completely liquid only above the higher point given, designated "complete liquation point." In the range of temperature between these two points the alloys are partly solid and partly liquid. In Grade No. 1 the amount of solid portion is so small in the range given that it is practically unnoticeable. In Grade No. 4 the proportion of solid and fluid metal in the range given makes this alloy suitable for use as wiping solder.

The data in this appendix do not constitute a part of these specifications. They are given merely to indicate to the purchaser the physical properties of the various alloys specified which can be expected of carefully manufactured alloys of the formulas indicated, and to constitute a guide to the purchaser in selecting the grade best suited for meeting the service condition for which the solder metal is to be used.

Table Showing Melting Points of Solder Metal.

Grade.	Formula.			Melting Point.		Complete Liquation Point.	
	Tin, per cent.	Lead, per cent.	Antimony, per cent.	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.
Tin	100.00	......	......	232	449.6	232	449.6
0 A	63.00	37.00	0.12	181	357.8	181	357.8
1 A	50.00	50.00	0.12	181	357.8	213	415.4
1 B	49.25	50.00	0.75	185	365.0	208	397.4
2 A	45.00	55.00	0.12	181	357.8	225	437.0
2 B	43.50	55.00	1.50	188	370.4	220	428.0
3 A	40.00	60.00	0.12	181	357.8	237	458.6
3 B	38.00	60.00	2.00	188	370.4	228	442.4
4 A	37.50	62.50	0.12	181	357.8	241	467.6
4 B	35.50	62.50	2.00	188	370.4	231	411.8
5 A	33.00	67.00	0.12	181	357.8	252	485.6
5 B	31.00	67.00	2.00	188	370.4	235	455.0
Lead	......	100.00	......	327	620.6	327	620.6

AMERICAN SOCIETY FOR TESTING MATERIALS

PHILADELPHIA, PA., U. S. A.

AFFILIATED WITH THE

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS

FOR

TINNED SOFT OR ANNEALED COPPER WIRE FOR RUBBER INSULATION.[1]

Serial Designation: B 33 – 19 T.

These specifications are issued under the fixed designation B 33; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

Product Covered.

1. These specifications cover tinned soft or annealed copper wire suitable for use in making rubber insulated wires and cables.

I. MANUFACTURE.

Manufacture.

2. The tinned wire shall be made by coating soft or annealed copper wire with pure tin. The copper used shall be of such quality and purity that after tinning it shall have the properties and characteristics hereinafter required.

II. CHEMICAL PROPERTIES AND TESTS.

Continuity of Coating.

3. The continuity of the tin coating shall be determined by the Sodium Polysulfide test, which shall be applied as specified in Sections 4 to 10.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. J. A. Capp, Chairman of Committee B-1 on Copper Wire, General Electric Co., Schenectady, N. Y.

(*A*) *Treatment of Samples.*

Length of Samples.

4. Samples shall have a length of about 6 in., and they shall be tagged or marked to correspond with the coil or reel from which they were cut.

Treatment of Samples.

5. The samples shall be thoroughly cleaned by immersion in benzine, redistilled petroleum ether, ether, or carbon tetrachloride for at least 3 minutes, then removed and wiped dry with a clean, soft cloth. The samples thus cleaned shall be kept in a clean, dry cloth until tested. The part of the sample to be immersed in the test solution shall not be handled. Care shall be taken to avoid abrasion by the cut ends.

(*B*) *Method of Testing.*

Immersion of Samples.

6. (*a*) A length of at least 4½ in. of the cleaned samples shall be immersed, in accordance with the following cycles, in test solutions maintained at a temperature between 15.5 and 21° C. (60 and 70° F.):

First: Immerse for 1 minute in HCl solution as hereinafter defined. Wash and wipe dry.

Second: Immerse for 30 seconds in sodium-polysulfide solution as hereinafter defined. Wash and wipe dry.

Third: Immerse for 1 minute in HCl solution. Wash and wipe dry.

Fourth: Immerse for 30 seconds in sodium-polysulfide solution. Wash and wipe dry.

(*b*) After each immersion the samples shall be immediately and thoroughly washed in clean water and wiped dry with a clean, soft cloth.

Examination of Samples.

7. After the above-described operations, the samples shall be examined in order to ascertain if copper exposed through openings in the tin coating has been blackened by the action of the sodium polysulfide. The sample shall be considered to have failed if by such blackening exposed copper is revealed. No attention shall be paid to blackening within ½ in. of the cut end.

Mechanical Test for Adhesion.

8. A mechanical test for adhesion of tinning may be made by bending the wire around a rod having a diameter equal to four times the diameter of the wire, and dipping the bent portion of

the wire in the sodium-polysulfide solution only, for 30 seconds. Any cracking or parting of the coating will be shown by blackening of the copper. Such cracking or parting of the coating will be a cause for rejection.

(*C*) *Testing Solution.*

9. (*a*) The hydrochloric-acid solution, specific gravity 1.008, shall be made in the following manner: Commercial HCl, sp. gr. 1.12, shall be diluted with distilled water to a specific gravity of 1.088 measured at 15°.5 C. (60° F.).

(*b*) A portion of HCl solution having a volume of 180 cc. shall be considered exhausted when there have been immersed in it for two cycles the number of test samples of any size as indicated in the following table:

DIAMETER, IN.	MAXIMUM NUMBER TO BE TESTED FOR TWO CYCLES IN 180 CC. OF ACID SOLUTION.
0.460 to 0.141	2
0.140 to 0.086	4
0.085 to 0.051	6
0.050 to 0.039	10
0.038 to 0.031	12
0.030 to 0.003	14

For wire whose diameter is between listed sizes, the number of samples shall be the same as for the next larger size indicated.

Sodium-Polysulfide Solution.

10. The sodium-polysulfide test solution, sp. gr. 1.142, shall be made in the following manner: A concentrated solution shall be made by dissolving sodium-sulfide crystals in distilled water until the solution is saturated at about 21° C. (70° F.), adding about 250 g. of flowers of sulfur per liter, and allowing to stand for at least 24 hours.

The test solution shall be made by diluting a portion of the concentrated solution with distilled water to a specific gravity of 1.142 at 15°.5 C. (60° F.). The sodium-polysulfide test solution should have sufficient strength to blacken thoroughly a piece of clean untinned copper wire in 5 seconds. A portion of test solution used for testing samples will not be considered exhausted until it fails to blacken a piece of clean copper as above described.

III. PHYSICAL PROPERTIES AND TESTS.

(*A*) *Mechanical.*

Tensile Properties.

11. (*a*) The tensile strength and elongation of the tinned copper wire shall conform to the values in Table I.

TABLE I.—TENSILE PROPERTIES.

Diameter, in.	Tensile Strength, max., lb. per sq. in.	Elongation in 10 in., min., per cent.
0.460 to 0.290	36 000	30
0.289 to 0.103	37 000	25
0.102 to 0.021	38 500	20
0.020 to 0.012	39 000	15
0.011 to 0.003	40 000	10

(*b*) For wire whose nominal diameter is between listed sizes, the requirements shall be those of the next larger size indicated in Table I.

(*B*) *Electrical.*

Resistivity.

12. The resistivity of the wire expressed in pounds per mile ohm at 20° C. (68° F.) shall not exceed the values in Table II.

TABLE II.—RESISTIVITY.

Diameter, in.	Resistivity, lb. per mile ohm at 20° C.
0.460 to 0.290	896.15
0.289 to 0.103	900.77
0.102 to 0.021	910.15
0.020 to 0.012	929.52
0.011 to 0.003	938.20

IV. PERMISSIBLE VARIATIONS.

Permissible Variations.

13. (*a*) The size shall be expressed as the diameter of the wire in decimal fractions of an inch.

(*b*) The permissible variation from nominal diameter shall be:

For wire 0.010 in. or over in diameter, 1 per cent under and 3 per cent over;

For wire under 0.010 in. in diameter, 0.0001 in. under and 0.0003 in. over.

(*c*) For coiled wire, each coil shall be gaged in three places; one near each end, and one approximately at the middle. For spools, approximately 12 ft. shall be reeled off and the wire shall be gaged in six places between the second and twelfth foot from the end.

(*d*) The coil or spool will be rejected if the average gage is not within the limits specified in Paragraph (*b*).

V. WORKMANSHIP AND FINISH.

Workmanship.

14. The tin coating shall consist of a smooth continuous layer, firmly adherent to the surface of the copper.

VI. INSPECTION AND REJECTION.

Inspection.

15. The manufacturer shall afford the inspector representing the purchaser, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection.

16. Wire which shows exposed copper by blackening after testing in the sodium-polysulfide solution, as described, or which fails to conform with the other requirements of these specifications, shall be rejected.

EXPLANATORY NOTE.

The coating of tin on copper wire is for the purpose of protecting the copper against the action of the rubber insulation. It is, therefore, necessary that the coating be continuous. The test in the sodium-polysulfide is for the purpose of determining whether or not the wire carries a continuous envelope of pure tin.

The thickness of the tin coating is necessarily varied. Under the same conditions of tinning the coating on all sizes of wire, excepting on fine wire, is approximately the same. The coating on fine wire is generally relatively heavier than that on coarse wire. It is not, therefore, correct to apply a larger number of cycles in the test on coarse wire than is applied to fine wire. It is probable that one cycle of the dip test would be sufficient to discover defects in tinned wire, but in order to make certain that no partially covered spots may escape attention, two cycles have been provided for. It has been found that the tin coating on copper wire consists of two parts, an envelope of pure tin on the outside, with an intermediate layer of copper-tin alloy. This tin alloy, as well as the amount of tin present, has an effect on the resistivity of the wire. Since the relative amount of tin coating and alloy is greater on the small wire than it is on the coarser wire, the resistivity of the wire increases as the size decreases. This also accounts for the decrease in elongation due to tinning soft wire.

AMERICAN SOCIETY FOR TESTING MATERIALS

PHILADELPHIA, PA., U. S. A.

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INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE METHODS
FOR
CHEMICAL ANALYSIS OF ALLOYS OF LEAD, TIN, ANTIMONY AND COPPER.[1]

Serial Designation: B 18 - 17 T.

These methods are issued under the fixed designation B 18; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

I. GENERAL METHOD.[2]

1. Dissolve 1 g. of the finely divided alloy by boiling in from 70 to 100 cc. of the following solution in a covered beaker: The solution is made by dissolving 20 g. of KCl in 500 cc. of water, then adding 400 cc. of concentrated HCl, mixing, and then 100 cc. of HNO_3 (sp. gr. 1.40). No decomposition between HCl and HNO_3 takes place in this solution in the cold. If complete solution of the alloy is difficult in the amount of the solution taken, more is added as required. Continue boiling until solution is evaporated to about 50 cc.

Lead. (*a*) Add 5 cc. of concentrated HCl and cool by placing beaker in ice water until the bulk of the lead has crystallized out as chloride. Then add slowly 50 cc. of 95-per-cent alcohol from a pipette, with constant stirring; stir for a few minutes longer after the alcohol has been added and place the beaker in ice water for ten minutes. Add 50 cc. more alcohol in the same way, allow to stand in ice water for 20 minutes and filter through 9-cm. paper into an 800-cc. beaker. Wash by decantation three times with a mixture of 95-per-cent alcohol and concentrated HCl (4 : 1) and wash paper twice with same mixture. With proper manipulation this treatment should uniformly precipitate all but 0.003 g. of lead. The most favorable conditions are obtained by allowing to stand, cold, over night before adding the alcohol.

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1920, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

[2] G. W. Thompson's method. See *Journal*, Soc. Chem. Ind., Vol. 15, p. 179.

Wash the lead chloride on paper back into beaker and wash paper several times with hot water, allowing washings to flow into beaker with the rest of the chloride. Finally, wash twice with a solution of hot ammonium acetate (the ammonium-acetate solution is made by taking one volume of ammonia water 0.900 sp. gr., adding to it one volume of water, and then 80-per-cent acetic acid until it is slightly acid to litmus) and heat until lead chloride is all dissolved. The solution should remain perfectly clear, turbidity indicating the presence of tin or antimony; even 1 mg. of tin or antimony will cause a slight but distinct turbidity. Add 15 cc. of saturated solution of $K_2Cr_2O_7$, heat until precipitate is of good orange color, filter on weighed Gooch crucible, wash with water, alcohol and ether, dry at 110° C., and weigh. Calculate to lead by the empirical factor 63.75.

Evaporate the filtrate from lead chloride by boiling on hot plate in the loosely covered 800-cc. beaker, and finally to dryness on water bath, with cover removed. Add 10 cc. of the solution of KOH (1 g. to 5 cc.) and after a few minutes 20 cc. of 3-per-cent H_2O_2. Test the solution by dropping into it a small piece of litmus paper, and, if acid, add more KOH, little by little, until it shows an alkaline reaction. Heat on water bath for 20 minutes, add 10 g. of ammonium oxalate, 10 g. of oxalic acid, and 200 cc. of water. Heat to boiling, pass H_2S with solution near boiling for 45 minutes, filter at once, and wash precipitate with hot water.

Tin. (*b*) Concentrate, if necessary, or if the tin in the portion of the sample taken for analysis amounts to 0.5 g. or over, add 5 g. more oxalic acid, and electrolyze over night, using cylindrical cathodes 2 by $1\frac{3}{8}$ in. diameter, of platinum wire gauze, with a current of about $\frac{1}{2}$ ampere. Usually by morning the solution will have become alkaline, in which case it may be taken for granted that the tin is all precipitated on the cathode. The best results are obtained, however, by regulating the current density so as to render the solution alkaline only a very short time before the cathode is to be removed; and it is desirable as a precaution to add 5 g. of oxalic acid after the solution has become alkaline, boil and re-electrolyze. Remove the cylinder, wash twice with water, and then with 95-per-cent alcohol, dry in oven, and weigh. Wash the precipitate of antimony and copper sulfides on the filter paper back into the beaker with the least amount of water possible and treat with 10 cc. of KOH solution (1 : 5), heat on a water bath until the undissolved matter is distinctly black, then filter through same paper it was washed from into a 12-oz. Erlenmeyer flask, wash, etc.

Copper.

(*c*) On filter the copper is obtained as sulfide with a small amount of lead which failed to be precipitated as chloride. (If it is desired to determine this lead, it can be done by separation from the copper as usual.) Dry and ignite precipitate in small casserole, dissolve in HNO_3, boil to expel nitrous fumes, neutralize with Na_2CO_3, add a few drops of ammonia, and determine volumetrically with KCN standardized against pure copper. If the amount of copper present is from 8 to 10 mg. or more, it is determined electrolytically in HNO_3 solution, and the small amount of lead may be obtained and weighed on the anode as dioxide.

If only small amounts (less than 10 mg.) of antimony and copper are present in the sample, the lead, which failed to be precipitated as chloride, may also fail to come down as sulfide on passing H_2S through the oxalic-acid solution. It will remain in the filtrate from the sulfides and will be deposited electrolytically with the tin on the cathode. This can be prevented by adding an oxalic-acid solution of a pure antimony salt equivalent to about 100 mg. of antimony just before passing H_2S. In this case antimony, if present in the sample, must be determined on a separate portion.

Antimony. (*d*) The solution of antimony sulfide in KOH should not amount to over 40 cc.; add 50 cc. of concentrated HCl and boil for some time in order to expel arsenic as arsenious chloride. Now add 25 cc. more of concentrated HCl and 1 g. $KClO_3$, boil until solution is colorless and free chlorine is driven off, filter into similar flask through mineral wool if sulfur has separated, wash out original flask with concentrated HCl, cool, add 1 g. of KI, 1 cc. of CS_2, and titrate for antimony with N/10 sodium-thiosulfate solution, 1 cc. of which equals 0.0060 g. of antimony.

This systematic method assumes the absence of other metals than lead, tin, antimony, and copper.

Arsenic. 2. *Determination of Arsenic.*—Arsenic is determined on a separate portion as follows: Weigh out 1 g. of the finely divided sample and transfer to a distillation flask, together with 10 cc. of ferric-chloride solution (sp. gr. 1.43) free from arsenic; 60 cc. of concentrated HCl; 20 cc. of water; 5 g. of KCl. Connect the flask with a condenser, heat slowly until solution is complete, and distill, boiling to as small a volume as possible. When cool add 50 cc. more concentrated HCl and redistill. Pass H_2S through the cold distillate for an hour, allow to settle, filter and weigh the arsenious sulfide on a Gooch crucible, washing with HCl, cold water, alcohol and CS_2. After drying and weighing, redissolve with ammonium-carbonate solution, wash thoroughly with water and reweigh the Gooch crucible, calculating the loss in weight to arsenic.

II. RAPID VOLUMETRIC METHODS FOR FACTORY CONTROL WORK.

DETERMINATION OF LEAD.

(MOLYBDATE METHOD.)

Lead. 3. Treat 1 g. of the finely divided alloy in a covered beaker with 2 to 5 g. of tartaric acid and 10 cc. of water. Add slowly with constant stirring 10 cc. of HNO_3 (1 : 1) and heat gently—not above 60° C.—until the bulk of the sample is dissolved. Complete the solution (of antimony and copper) by heating on steam bath, and, if necessary, adding two or three drops of HNO_3 (concentrated). This treatment should give a clear solution, with formation of no metastannic acid (H_2SnO_3). Add slowly 10 cc. of H_2SO_4 (1 : 1) with constant stirring and then evaporate until nitrous fumes are no longer given off; but the evaporation should be stopped before the tartaric acid begins to char. Cool, dilute and filter off lead sulfate, washing with dilute H_2SO_4 (1 : 10).[1] Place the precipitate and filter in a flask, add 10 cc. of strong HCl and boil until the filter is well disintegrated, then add 15 cc. of strong HCl, 25 cc. of cold water and 25 cc. of strong ammonia water, Now color with a little litmus solution, make slightly alkaline with ammonia if not already so, and then make distinctly acid with strong acetic acid. Heat to boiling and see that the lead sulfate is entirely dissolved, then dilute to about 200 cc. with boiling-hot water and titrate with standard ammonium-molybdate solution as follows: Pour about two-thirds of the hot lead solution into a large beaker and run the molybdate solution into it from a burette until a drop from the beaker, when placed on a glazed porcelain plate and touched with a drop of a solution of tannic acid (about 0.1 g. dissolved in 20 cc. of water), gives a brown or yellow tinge. Now add more of the lead solution from the flask and continue the titration until the end-point is again passed. Continue thus to approach the true end-point, using more caution each time. Finally, when only a few cubic centimeters remain in the flask, pour the entire mixture in the beaker into the flask and then back into the beaker again and finish the titration two drops at a time. When the final yellow tinge is obtained, some of the immediately preceding tests may have developed a tinge also. From the reading of the burette deduct the volume of two drops for each test thus showing a color. Multiply the corrected reading by the percentage value of 1 cc. of the molybdate solution in lead to obtain the percentage of lead in the sample.[2]

The ammonium-molybdate solution is made by dissolving about 4.74 g. of ammonium molybdate in water and making up to one liter. It is standardized by treating about 0.2 g. of pure lead foil in exactly the same way as described for the treatment of the sample. This method is not accurate for alloys containing less than 2 per cent of lead.

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[1] See "The Analysis of Non-Ferrous Alloys," Ibbotson and Aitchison, p. 192, Method II, and "Technical Analysis of Brass," Price and Meade, p. 156.

[2] "Technical Methods of Ore Analysis," A. H. Low, pp. 129 and 131.

DETERMINATION OF TIN.

(PEARCE-LOW IODINE METHOD.)

Tin. 4. Weigh 0.2 to 1.0 g. (depending on the percentage of tin) of the finely divided alloy into a 12-oz. wide-mouth conical flask. Add 20 cc. of concentrated HCl and when most of the soluble metal is dissolved add $KClO_3$, a little at a time, until solution is complete. Boil off all the chlorine and then add 50 to 75 cc. of concentrated HCl, depending on the amount of antimony present. Make the solution up to a volume of 200 cc. with water. Prepare a nickel coil by rolling 6 sq. in. of heavy sheet nickel ($1\frac{1}{2}$ by 4 in.) into a loose roll of such a size that it may be easily inserted into the flask. Leave a narrow strip of nickel attached to one side of the coil and long enough to reach above the top of the flask when the coil is on the bottom. Place the coil in the solution in the flask, bend the nickel strip over the edge and cover with a small watch glass. Heat to boiling and maintain gentle ebullition for 30 minutes after all the iron which may be in the solution is reduced, which may be told by the yellow color of the solution changing to a pale green. Remove the flask from the hot plate and at once, while the solution is still hot and hydrogen still being evolved, place the rubber stopper carrying the tube from a CO_2 generator in the neck of the flask. Start the current of CO_2 and place the flask in the cooling trough.

When the solution in the flask has cooled to room temperature remove the stopper and drop in two $\frac{1}{2}$-in. cubes of crystallin marble. Remove the nickel coil, washing it with cold HCl solution (1 strong acid : 3 water), as it is withdrawn from the flask. This washing solution must be boiled to expel any free chlorine and then cooled before using. Add a little starch solution and titrate at once with standard iodine solution until the characteristic blue color indicates the end point.

The standard iodine solution most convenient for this titration is prepared by dissolving 10.7 g. of iodine in 50 cc. of water containing 20 g. of KI in solution, and making up to one liter with water. This can be standardized with pure tin or with a solution of sodium thiosulfate of exactly known value.[1]

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[1] See "The Volumetric Determination of Tin," R. L. Hallett, *Journal*, Soc. Chem. Ind., Vol. XXXV, No. 21.

DETERMINATION OF ANTIMONY.

(LOW'S PERMANGANATE METHOD.)

Antimony. 5. Treat 1 g. of the finely divided alloy in a 300-cc. Kjeldahl flask with 10 to 15 cc. of concentrated H_2SO_4 and heat over a Bunsen flame until the alloy is thoroughly decomposed and all separated sulfur has been driven off. Do not drive off all free H_2SO_4, but have from 7 to 10 cc. left to keep the melt from getting hard on cooling. Cool, add 20 cc. of water and 20 cc. of concentrated HCl and boil to make sure that all SO_2 is driven off. If arsenic is present in the alloy in only small amounts as an impurity it will be volatilized here and not interfere with the determination of antimony. However, the solution should in no case reach a temperature of 120° C. or over after the addition of HCl or there is danger of volatilizing antimony chloride. Cool and add water to a total volume of 200 cc., adjusting the strength of HCl to 1 : 10 for small amounts of antimony, or 1 : 5 for larger amounts. Titrate the cold solution rapidly with $KMnO_4$ solution, which has been standardized against pure metallic antimony treated exactly as described above for determination of the alloy. The true end point is reached when the whole solution is colored pink by one drop after agitation. The end point is sharp but the color may soon disappear, owing to the amount of HCl present.[1]

DETERMINATION OF COPPER.

Copper. 6. Dissolve 1 g. of the fine sawings in a No. 3 beaker in 45 cc. of strong HCl and 5 cc. of strong HNO_3. Boil down to about 15 or 20 cc. to expel free chlorine. Remove from the plate and wash down the sides of the beaker and cover glass with a fine jet of HCl (sp. gr. 1.10) from a wash bottle, using as little as possible. Dilute with water to about 75 cc. and add 5 g. of tartaric acid dissolved in 15 or 20 cc. of water. Make alkaline with ammonia till a clear blue solution is obtained and then add strong HCl drop by drop till the blue changes to light green and a slightly acid solution is obtained. If any lead chloride remains undissolved, heat on the plate a little below boiling till it is in solution. The solution should now be clear and hot. Add 2 cc. of stannous-chloride solution (225 g. to 1000 cc. of 1.10 HCl). Follow at once with 0.5 g. of potassium sulfocyanate dissolved in a little water. The copper precipitates completely as CuSCN and in a perfectly pure condition, barring a fractional part of a milligram of lead that seems to be carried down. Warm on the hot plate for a few minutes and filter through a single paper containing a little paper pulp. Wash thoroughly with hot water.[1]

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[1] See "Determination of Antimony and Tin," W. H. Low, *Journal*, Am. Chem. Soc., Vol. XXIX, p. 66; and "Rapid Analysis of Babbitt Metal," Percy H. Walker and H. A. Whitman, *Journal of Industrial and Engineering Chemistry*, Vol. I, p. 519.

Dry and ignite the precipitate in a small porcelain casserole or crucible, dissolve in a small amount of HNO_3, and boil to expel nitrous fumes. If the copper in the sample amounts to less than 8 to 10 mg., determine volumetrically with KCN as described under "General Method." If the amount of copper present is from 8 to 10 mg. or more, determine volumetrically as cuprous iodide, as follows:

Transfer the HNO_3 solution of copper to a flask of 250 cc. capacity, add 5 cc. of strong bromine water and boil until all nitrous fumes and bromine are expelled. Add a slight excess of ammonia and boil the excess off, then add strong acetic acid in slight excess, cool, add 3 g. of KI and titrate at once with N/10 sodium-thiosulfate solution until the free iodine is nearly removed, then add some starch liquor and continue the titration cautiously until the color due to free iodine has entirely vanished.[2]

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[1] Method of separation used by R. S. MacPherran, Chief Chemist, Allis-Chalmers Manufacturing Co.

[2] "Technical Methods of Ore Analysis," A. H. Low, p. 79.

AMERICAN SOCIETY FOR TESTING MATERIALS

PHILADELPHIA, PA., U. S. A.

AFFILIATED WITH THE

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE METHODS
FOR
BATTERY ASSAY OF COPPER.[1]

Serial Designation: B 34 – 19 T.

These methods are issued under the fixed designation B 34; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

APPROVED BY THE SUPERVISORY COMMITTEE ON STANDARD METHODS OF ANALYSIS, AMERICAN CHEMICAL SOCIETY.

The methods that follow are those originally proposed by Heath[2], whose work has been checked and elaborated by Keller, Ferguson and others.

The methods are those generally accepted in the United States for standard analysis in all the larger laboratories of both producers and consumers of copper and copper products.

GENERAL INSTRUCTIONS.

Sampling Ingots.—Select six ingots at random from the lot. Considering three ingots as a rectangular unit, drill one hole in each ingot, one at the center and one at each end of a diagonal of the rectangle. Drill each hole entirely through the ingot, starting from the bottom. Start the drill on the surface sufficiently to remove the oxide before commencing to collect the drillings for the sample. Run the drill so as to prevent oxidation of the chips. Discard all drillings carrying oxide from the "set," or burned by the drill. Use no lubricant on the drill, and if the sample shows oil or grease, remove this with ether. Sift all drillings on a screen with 250 meshes per sq. cm. in order to remove material which is ground between the drill and sides of the hole. Extract with a strong magnet any iron which may have come from the drill. Keep the drillings in air-tight bottles.

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1920, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

[2] Heath, *Transactions*, Am. Inst. Min. Engrs., Vol. 27, pp. 390–400 (1897).

Weights.—Weights shall be calibrated and frequently rechecked. It is recommended[1] to use a special 5-g. brass weight in weighing the samples and to have the weight of the sample always within 5 mg. of 5 g. When the cathode with its deposit is finally weighed the identical weights are to be used with which the cylinder was tared, plus the special 5-g. brass weight. This brings all the change or deficiency in the final weight on a small fractional weight and the beam and rider.

Electrodes.—The cathode is a platinum sheet of 5 by 10 cm. giving a depositing surface, counting both sides, of 100 sq. cm. This sheet is formed into a cylinder of the open type, and the stem is riveted and soldered with gold to the middle of the sheet. There should be no seam which cannot be cleansed completely by two washings. The anode is made from 1-mm. platinum wire, formed into a spiral of seven turns having a diameter of 12.5 mm. and a height of 38 mm., the stem being straight and 125 mm. long.

ASSAY OF ELECTROLYTIC AND LOW-RESISTANCE LAKE COPPER.

The method described below is applicable to such grades of electrolytic and low-resistance lake copper as are covered by the Standard Specifications for Lake Copper Wire Bars, Cakes, Slabs, Billets, Ingots and Ingot Bars (Serial Designation: B 4) and for Electrolytic Copper Wire Bars, Cakes, Slabs, Billets,

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[1] Greenwood, U. S. Metals Refining Co., Personal Communication.

Ingots and Ingot Bars (Serial Designation: B 5), of the American Society for Testing Materials.[1] The silver is deposited with the copper and is included as such; when it is desired to correct for the silver this is determined in a larger separate sample and the amount found is deducted from the deposit of copper plus silver.

METHOD.

Place 5 g. of the drillings in a tall lipless beaker which is provided with a well-fitting cover glass, and add a mixture of 7 cc. of HNO_3, sp. gr. 1.42, 10 cc. of H_2SO_4, sp. gr. 1.84, and 25 cc. of water. This mixture[2] is used as a stock "Assay Solution," 42 cc. being measured for each sample. The electrolysis beakers are from 100-125 mm. tall and 55 mm. in diameter across the bottom, with a total capacity of 225 to 300 cc. After the assays have stood for a few minutes and the action has nearly ceased, place them on a steam bath having a temperature of 80 to 90° C. and allow them to remain there until solution is completed and the red fumes have disappeared. Wash the cover and the sides of the beaker and dilute the solution to 150 cc. and electrolyze.

During electrolysis, cover the beakers with two pairs of split watch glasses placed at right angles to each other. The current[3] in each solution should be one ampere, which will require about 10 volts if the assays are arranged in parallel. It is convenient to start the assays at night; after about 15 hours wash the cover glasses, electrodes and beakers and reduce the current to 0.6 ampere per solution. As soon as the cathodes begin to evolve gas reduce the current to 0.4 ampere per solution. When this occurs take out about 1 cc. of liquid, place it in a depression in a porcelain test plate and add two or three drops of fresh H_2S water. If the slighest discoloration occurs continue the electrolysis, repeating the test until there is no discoloration whatever.[1] If possible the assay should finish without decided evolution of gas.

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[1] 1918 Book of A.S.T.M. Standards.

[2] Use of the dilute solution above described prevents a violent reaction and a consequent loss of copper with the vapors. The solution should not be boiled, since this likewise may cause a loss of copper.

[3] By the use of rotating anodes, gauze or perforated electrodes or the Frary solenoid, it is possible to use a high current density and to reduce the time required for depositing the copper to about four hours. Good results can be obtained by experienced workers, but there is much more chance for error. The slow or over-night method, which is more certain and which requires less of the operator's time, is therefore recommended.

Without interrupting the current, siphon off the acid solution, at the same time filling the beakers with distilled water. Remove the cathodes quickly and rinse them in distilled water and two successive baths of alcohol. An experienced operator can quickly remove a cathode and immerse it in water without loss. Throw off the excess alcohol by a quick motion of the hand and ignite the remainder by bringing the cathode quickly to the flame of an alcohol lamp; then keep the cathode moving continually while the alcohol burns. Weigh as metallic copper.

Accuracy.—All assays shall be made in duplicate and shall check within an outside limit of 0.015 per cent of copper.

NOTES.

The deposition of the silver with the copper is said to work well up to the limit of 0.3 per cent silver, that is, 100 oz. per ton.

The method of burning off the alcohol in the flame of an alcohol lamp dries the cathode without causing oxidation, whereas drying in an oven to 100° C. generally causes increase in weight.

ASSAY OF LOW-GRADE OR CASTING COPPER.

For all grades of copper which are not included in the specifications of the American Society for Testing Materials, previously referred to, as Electrolytic and Low-Resistance Lake Copper the procedures given below are recommended. These brands may contain a considerable amount of arsenic and some antimony, tellurium, bismuth and nickel. (See Notes.)

METHOD I.

Carry out the assay exactly as given for Electrolytic and Low-Resistance Lake Copper. Place the cathode in a clean beaker, cover with a watch glass perforated with a small hole just large enough to accommodate the stem of the electrode, add 42 cc. of "Assay Solution" and water enough to cover the sheet. Let it stand upon the steam bath until the coating is dissolved. Re-electrolyze in the regular manner.

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[1] It has been shown by Heath, *Journal of Industrial and Engineering Chemistry*, Vol. 4, p. 404 (1912), that a few thousandths of a per cent of copper may remain in the solution without being detected by the test on the spot plate. This amount of copper is negligible in many instances, but when necessary to make exact determinations, as in the complete analysis of copper, make the solution, after electrolysis, slightly alkaline, neutralize with HCl, sp. gr. 1.19, adding 3 cc. excess, evaporate to 50 cc. and precipitate with H_2S. Filter off the copper sulfide, treat with HNO_3 and H_2SO_4, deposit the small amount of copper from the solution by electrolysis and add it to that obtained in the original determination.

METHOD II.[1]

Dissolve a 5-g. sample in 42 cc. of the "Assay Solution" and evaporate until all the HNO_3 is expelled. Redissolve in 70 cc. of water and add 3 cc. of ferric nitrate solution (1 cc. = 0.01 g. of iron). Transfer the solution to a lipped beaker and place the original beaker under a funnel fitted with a small filter paper. Precipitate the iron from the hot liquid by ammonia, filter and wash out salts. Place the solution on a hot plate to concentrate, reprecipitate the hydroxide from dilute H_2SO_4 in a very small volume of solution and add the filtrate to the main solution. Reprecipitate the hydroxide once more from dilute H_2SO_4, filter, wash thoroughly and add the filtrate to the main solution. Make acid with dilute H_2SO_4 and add 2 cc. of HNO_3, sp. gr. 1.42. Deposit the copper as in the method for Electrolytic and Low-Resistance Lake Copper.

METHOD III.[2]

(FOR COPPER CONTAINING ONLY TRACES OF ANTIMONY OR BISMUTH BUT SUFFICIENT SELENIUM OR TELLURIUM TO INTERFERE.)

Dissolve the 5-g. sample in 42 cc. of "Assay Solution" and evaporate until fumes appear, or until the residue is white. Redissolve in 60 cc. of water and saturate the boiling hot solution for 10 minutes with SO_2 gas, removing the solution from the lamp when the gas is started. The gas may be generated by dropping cold saturated sodium sulfite solution into strong H_2SO_4. It is also conveniently obtainable in cylinders which are fitted with a valve. Let the precipitate settle for a few hours, filter and wash with a little hot water. Boil the filtrate gently to remove most of the SO_2 gas. Ignite the filter in a porcelain crucible to volatilize the selenium[1] and tellurium, redissolve the oxidized residue in 1.5 to 2 cc. of HNO_3 and add to the main solution. Deposit the copper as in the method for Electrolytic and Low-Resistance Lake Copper.

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[1] Heath (Senter modified), *Journal* Am. Chem. Soc., Vol. 26, p. 1123 (1904).

[2] Heath, *Ibid.*, Vol. 26 p. 1123 (1904); Keller, *Transactions*, Am. Inst. Min. Engrs., p. 2098 (1913), *Bulletin No. 80*.

METHOD IV.[2]

(FOR COPPER HIGH IN ARSENIC ONLY.)

Modification A.—Dissolve the sample in 42 cc. of the "Assay Solution" in the regular way and add 5 g. of ammonium nitrate. Electrolyze as usual.

Modification B.—Dissolve the sample in 60 cc. of the "Assay Solution" instead of 42 cc. Electrolyze as usual.

Accuracy.—All assays shall be made in duplicate and shall check with an outside limit of 0.015 per cent of copper.

NOTES.

It has been recommended[3] to use with solutions of the Low-Grade or Casting Coppers about 2 cc. of an addition agent prepared by boiling "hard oil" with strong HNO_3, cooling and removing the grease. This, it is said, will permit the use of high current densities and yet allow the copper to be deposited pure and bright. Moreover, it is said that arsenic and antimony, when present, do not contaminate the copper. It seems probable,[4] however, that copper deposited from such solutions is not quite pure and that it is more accurate to purify the cathode deposit (Method I) or to give a preliminary treatment to the solution (Method II).

Method II is recommended in preference to Method I, which should be used only in the presence of small amounts of impurities.

In Method IV for copper high in arsenic, Modification B is to be preferred.

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[1] The selenium is said to be carried down by SO_2 as a selenide of silver, but the roasting sufficiently removes the elements selenium and tellurium. When silver is to be removed, the selenium, etc., are thrown down with the silver by the SO_2 gas and the precipitation of silver is then completed by the addition of chlorides or HCl.

[2] *Modification A.*—Heath, *Journal*, Am. Chem. Soc., Vol. 26 p. 1124 (1904); *Modification B.*—Heath, *Journal of Industrial and Engineering Chemistry*, Vol. 3 p. 75 (1911).

[3] Guess, *Transactions*, Am. Inst. Min. Engrs., Vol. 36, p. 605 (1905).

[4] Keller, *Ibid.*, p. 2099 (1913), *Bulletin No. 80*; Heath, *Journal of Industrial and Engineering Chemistry*, Vol. 3, p. 75 (1911).

AMERICAN SOCIETY FOR TESTING MATERIALS
PHILADELPHIA, PA., U. S. A.
AFFILIATED WITH THE
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE METHODS
FOR
CHEMICAL ANALYSIS OF PIG LEAD.[1]

Serial Designation: B 35 – 19 T.

These methods are issued under the fixed designation B 35; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

The complete chemical analysis of pig lead includes, ordinarily, the determination of the following elements: silver, arsenic, antimony, tin, bismuth, copper, cadmium, iron, zinc, nickel and cobalt and manganese.

Silver, arsenic and bismuth are determined upon separate portions.

DETERMINATION OF SILVER.

Weigh 100 g. of the sample into a 3-in. scorifier and heat in a muffle furnace until the assay "covers." Pour into an iron mold and allow to cool. Free the resulting lead button from PbO, scorify again and pour as before. The button last obtained should not weigh over 20 g. and can be cupelled directly. Weigh the silver button obtained upon an assay balance. If the amount of silver is large, the button should be examined for gold, in the usual manner.

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1920, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

DETERMINATION OF BISMUTH.

In the determination of bismuth there are three cases to be considered: Case I, Ordinary Method; Case II, where the amount of bismuth is very small; Case III, where there are appreciable amounts of tin and antimony present in the sample.

Case I.—Dissolve 20 g. of the sample in a 400-cc. beaker with 100 cc. of HNO_3 (1:4), with the aid of heat. When solution is complete, add dilute ammonia (1:2) with constant stirring, drop by drop, until a faint opalescence appears. The ammonia can be conveniently added from a burette. If an actual precipitate is formed, redissolve by the addition of a small amount of HNO_3 (1:4) and repeat the addition of ammonia. Now add 5 cc. of HCl (1:9), fill the beaker with hot water, bring to boiling, and allow to stand warm. Two hours on the steam bath is sufficient, but if time permits it is convenient to allow the assay to stand over night. In that case, the precipitate of bismuth oxychloride generally settles so completely that the clear supernatant solution can be decanted. The assay, while standing, must not reach the boiling temperature. Filter the assay upon a 7-cm. paper. Transfer the precipitate completely to the paper by means of a "policeman" and wash twice with hot water. Carefully examine the filtrate, washings, and any decanted liquid and reject if clear. Dissolve the precipitate by dropping around the edges, from a 5-cc. pipette, 5 cc. of boiling HCl (1:9), receiving the solution in the original beaker. Wash the paper thoroughly with hot water, fill the beaker with water, bring to boiling, and allow to stand as before. Filter the bismuth oxychloride upon a weighed Gooch crucible, wash thoroughly with water, once with alcohol, once with ether, and dry upon the hot plate. Cool and weigh.

Case II.—If a sample contains so small an amount of bismuth that it cannot be determined by the above method, proceed as follows: Dissolve 100 g. of the sample in 500 cc. of dilute HNO_3 (1:4). When solution is complete, allow to cool and add a 10-per-cent solution of pure Na_2CO_3 little by little until a slight permanent precipitate has formed. Then add 50 cc. of the 10-per-cent Na_2CO_3 solution, bring to boiling, allow to stand warm until the supernatant liquor is clear again, filter and reject the filtrate. Dissolve the precipitate without washing by slowly pouring hot 1 : 4 HNO_3 around the edges of the filter paper, using no more acid than necessary. Wash the paper once with hot water and determine bismuth in the filtrate as outlined in Case I. When the sample contains a small amount of bismuth, it is often difficult to ascertain when the correct amount of ammonia has been added to the nitrate solution. In this case, a small piece of litmus paper is placed in the solution, and the ammonia added very gradually until the litmus paper indicates a neutral reaction.

Case III.—When the sample contains comparatively large amounts of tin or antimony, the residue left after the solution of the lead in the nitric acid obscures the opalescence formed upon the addition of ammonia. In this case, use a piece of litmus paper as above, and after the first precipitation of bismuth oxychloride has been filtered off and washed, proceed as follows: Dissolve the bismuth by dropping around the edges of the paper 10 cc. of boiling HCl (1:2), receiving the solution in the original beaker. Discard the paper after washing. Dilute the solution to about 200 cc. with fresh H_2S water and then pass H_2S gas through the hot solution for 15 minutes. Filter and wash with hot water. Remove any tin or antimony present by washing three times with a solution containing 4 parts of H_2S water and 1 part of KOH solution (1:5). Wash the precipitate again with hot water, place it together with the filter paper in a 100-cc. beaker, add 20 cc. of HNO_3 (1:4), boil until sulfides are completely dissolved and the paper well pulped. Filter the solution, receiving the filtrate in the original beaker, and wash well. Determine bismuth in the filtrate as in Case I.

NOTE.

If the original sample contains more than 0.25 per cent of bismuth, it is preferable to use a 10-g. charge.

DETERMINATION OF ARSENIC.

Dissolve 111.11 g. of the sample in 550 cc. of HNO_3 (1:4). When solution is complete wash into a liter graduated flask, add 75 cc. of H_2SO_4 (1:1), cool, and make up to the mark with water. Transfer to a large beaker, rinsing out the flask with 25 cc. of water, which is equivalent to the volume of precipitated lead sulfate. Mix thoroughly, allow to settle and filter off 900 cc., equivalent to a 100-g. charge. Evaporate in a large porcelain dish until only enough H_2SO_4 is left to moisten the residue. When cool, wash into a small distilling flask with 60 cc. of concentrated HCl and 20 cc. of water, cleaning the dish carefully. Add 10 g. of ferrous sulfate and distill, boiling to as small a volume as possible. When cool add 50 cc. more concentrated HCl and redistill. Pass H_2S gas through the cold distillate for 45 minutes. Filter, and weigh the arsenious sulfide on a Gooch crucible, washing with cold water, alcohol and CS_2. After drying and weighing, redissolve with $(NH_4)_2CO_3$ solution and reweigh the Gooch crucible, calculating the loss in weight to arsenic.

DETERMINATION OF REMAINING METALS.

Dissolve 222.23 g. of the sample in 1100 cc. of HNO_3 (1:4), using a 1300-cc. beaker. When solution is complete examine for color and turbidity. A residue indicates the presence of antimony, tin, possible arsenic, or sulfur as lead sulfate. If clear, wash the solution at once into a 2000-cc. graduated flask. In case of a residue, however, dilute to about 1100 cc. and allow to stand until the supernatant liquor is clear. Decant as much as possible into a 2000-cc. flask, filter the remainder and receive the filtrate in the same flask. Wash the precipitate well and then place it, together with the filter paper, in a 100-cc. beaker and add 20 cc. of tartaric acid mixture (50 g. of tartaric acid dissolved in 250 cc. of water and mixed with 250 cc. of concentrated HCl). Heat to boiling and when the paper is well pulped allow to digest warm for ½ hour. Now add 50 cc. of hot water, filter and wash. It has been found that even this treatment occasionally fails to dissolve stannic acid completely. Therefore, carefully dry the residue and ignite. If any appreciable residue remains, brush it into a small silver dish containing 1 g. of molten KOH. Fuse for 5 minutes, and after cooling dissolve in as little hot water as possible and add to the above mentioned tartaric acid filtrate. Render this solution just alkaline with ammonia and then just acid with HCl, and saturate hot with H_2S gas. After digesting for ½ hour on the steam bath, pass H_2S through the solution again for 15 minutes. Filter and wash with slightly acidified H_2S water. Reject the filtrate. Wash the sulfides from the paper into the original beaker and add 5 cc. of KOH solution (1:5) for every 25 cc. volume present. Digest hot for 5 minutes and filter through the original paper into a small flask graduated to 110 cc. After washing with H_2S water containing a little of the KOH solution, cool the filtrate and make up to the mark. Mix and reserve 100 cc. as alkaline sulfide solution No. 1. The precipitate may be discarded.

Add slowly to the main solution in the 2000-cc. flask 150 cc. of H_2SO_4 (1:1). After cooling and filling up to the mark, pour into a clean 3-liter flask provided with a rubber stopper. Rinse the flask out with 50 cc. of water, which is equivalent to the volume of lead sulfate and is added to the portion. After mixing thoroughly by shaking, allow the precipitate to settle and filter off 1800 cc. of the liquid. This is equivalent to a 200-g. charge. Place this in a No. 9 porcelain evaporating dish and evaporate, first over a free flame and later on the hot plate until only enough H_2SO_4 is left to moisten the residue remaining. Add 50 cc. of water and, after digesting warm for a short time, wash the solution into a 250-cc. beaker, cleaning the dish carefully. Allow the solution to digest on the steam bath for 4 or 5 hours, preferably over night, to insure the complete solution of all soluble salts. Then filter, wash and evaporate the filtrate to 200-250 cc. The residue of lead sulfate may contain some tin, antimony, or possibly arsenic. Therefore place it, together with the filter paper, in a 100-cc. beaker and treat with 20 cc. of the tartaric acid mixture. Boil for 5 minutes, dilute with 50 cc. of hot water and filter. Make the filtrate alkaline with ammonia and just acid with HCl, and obtain the tin, antimony and arsenic as previously described, reserving the whole of the alkaline sulfide solution as solution No. 2. Reject the sulfide residue.

To the filtrate from the lead sulfate, add ammonia until the neutral point is reached, and then for every 50 cc. of the solution present add 2 cc. of concentrated HCl. Pass H_2S gas into the hot solution until saturated, digest for $\frac{1}{2}$ hour on the steam bath and again pass H_2S gas into the solution. Filter and wash with H_2S water slightly acidified. The filtrate will contain any iron, zinc, nickel, cobalt and manganese; copper, cadimum, lead, silver, bismuth, tin, antimony and arsenic will be found in the precipitate. Separate the last three metals with KOH solution as usual, obtaining an alkaline sulfide solution No. 3.

To sum up, three alkaline sulfide solutions have been obtained, containing tin, antimony and arsenic, a precipitate of metallic sulfides containing copper, lead, etc., and a solution containing iron, zinc, nickel, etc.

DETERMINATION OF ANTIMONY AND TIN.

Wash the alkaline sulfide solutions Nos. 1, 2 and 3 into a 600-cc. beaker, and acidify with 5 cc. of HNO_3 and 20 cc. of HCl. Evaporate the solution to dryness on the steam bath. Dissolve the residue in 200 cc. of water, add 10 g. of oxalic acid and 10 g. ammonium oxalate and heat the solution until it is clear. Then pass H_2S gas through the boiling solution for 45 minutes. Filter off the precipitate, consisting of arsenic and antimony sulfides, and wash with hot water. Determine tin electrolytically in the filtrate, continuing the electrolysis until all the oxalic acid is decomposed and the solution becomes alkaline. Dissolve the deposit on the cathode with a small amount of HCl and examine qualitatively for tin.

Dissolve the sulfides of arsenic and antimony in KOH as usual, collecting the filtrate in a 500-cc. Erlenmeyer flask. Add 50 cc. of concentrated HCl and boil the solution until about 30 cc. are left. Expel the arsenic as chloride. Now oxidize the solution with a pinch of potassium chlorate and boil until no more chlorine remains. Cool and add 5 cc. of a 10-per-cent solution of potassium iodide. Titrate the liberated iodine with N/10 sodium thiosulfate solution, using carbon disulfide as an indicator. 1 cc. of N/10 $Na_2S_2O_3 = 0.006$ g. of antimony.

DETERMINATION OF COPPER AND CADMIUM.

The treatment of the sulfides of copper, etc., depends upon the amount of copper present. If the percentage of copper exceeds 0.0025 per cent Method I should be used, otherwise Method II.

Method I.—Place the filter containing the sulfides in a 100-cc. beaker and add 20 cc. of HNO_3 (1 : 4). Heat with occasional stirring until the paper is thoroughly pulped and the sulfides are completely dissolved. Filter into a 250-cc. beaker. Dry the residue, which generally contains a small amount of copper, ignite in a porcelain crucible, boil with 5 cc. of HNO_3

(1 : 1), and wash into the main portion. The solution should not have a volume of over 100 cc. Render it strongly alkaline with ammonia, and add 5 g. of potassium cyanide, then saturate it in the cold with H_2S gas. Copper remains in the solution while lead, silver, bismuth and cadmium are precipitated. Filter the solution and evaporate the filtrate to a volume of 20 to 30 cc. in a 4-in. porcelain casserole. Boil until solution is complete. Add 20 cc. of H_2SO_4 (1 : 1) and evaporate the solution under a hood until dense fumes of H_2SO_4 escape. Cool, dilute, and warm until copper sulfate is all dissolved. Now filter, if necessary, into a 200-cc. beaker, render just alkaline with ammonia, make acid by the addition of 3 cc. of HNO_3 per 100 cc. of solution, and electrolyze for copper.

Dissolve the precipitate of sulfides in the usual manner with 20 cc. of HNO_3 (1:4). Add 1 cc. of a 1-per-cent solution of NaCl to the solution, still containing the pulped filter, and digest for ½ hour. Then filter and wash, thus removing the silver present as chloride, which is rejected. Make the filtrate, not exceeding 100 cc., alkaline with a slight excess of Na_2CO_3 and add 5 g. of potassium cyanide. Digest warm for 1 hour. Filter and wash with 5-per-cent Na_2CO_3 solution. Reject the precipitate of bismuth. Now add a few cubic centimeters of ammonium sulfide solution to the filtrate, when any cadmium will be precipitated as yellow cadmium sulfide. Filter upon a weighed Gooch crucible and weigh as cadmium sulfide. If an appreciable amount of cadmium sulfide is found, it should be converted to and weighed as cadmium sulfate, according to method for cadmium under Standard Specifications for Spelter (Serial Designation: B 6 - 18) of the American Society for Testing Materials.

Method II.—Place the paper containing the sulfides in a porcelain crucible, dry carefully and ignite. When the carbon has been all burned off, cool and dissolve the residue in 5 to 10 cc. of HNO_3 (1:1). After evaporating to a volume of 1 to 2 cc., add 1 cc. of H_2SO_4 (1:1). Then evaporate the solution until fumes appear, cool, dilute, add a few drops of 10-per-cent NaCl solution, and filter off the lead sulfate and silver chloride. Again evaporate the filtrate until fumes of H_2SO_4 appear, and when cold dilute and neutralize with a saturated solution of Na_2CO_3. Then add about six drops of concentrated ammonia and titrate the solution with a standard KCN solution until the blue color is discharged. (The KCN solution is made by dissolving 2 g. of the salt in a liter of water and is standardized against a known amount of copper treated as in the analysis.)

The cadmium can be obtained by making this solution, titrated for copper, strongly alkaline, diluting a little, and adding 5 g. of KCN. Saturate the solution cold with H_2S gas, filter, discard the filtrate and treat the precipitate for cadmium as described in Method I.

DETERMINATION OF IRON.

Evaporate the filtrate containing iron, zinc, etc., to 100 cc. and oxidize with a few drops of HNO_3. Separate the iron with ammonia as usual, making two separations, and receive the filtrate in a 500-cc. Erlenmeyer flask. Redissolve the iron hydroxide with hot HCl (1:1) or dilute H_2SO_4 and determine the iron volumetrically by any of the standard methods.

DETERMINATION OF ZINC.

Add to the filtrate from the iron hydroxide 1 cc. of cochineal indicator, and render just neutral with HCl. Then add 15 drops of 2N HCl for each 100 cc. of the solution. Saturate cold with H_2S gas and allow the flask, loosely stoppered, to stand over night. Filter and wash with H_2S water acidified in the same manner as above described. Dry the precipitate of zinc sulfide, carefully ignite in a porcelain crucible and weigh as zinc oxide.

DETERMINATION OF NICKEL AND COBALT.

Render the filtrate just alkaline with ammonia and saturate with H_2S. Heat to boiling and then make just acid with acetic acid, add 20 cc. of neutral ammonium acetate solution, and boil until the sulfides of nickel and cobalt separate out. Filter and wash with warm H_2S water containing about 20 cc. of neutral ammonium acetate solution per 100 cc. Dry the precipitate and paper in a porcelain crucible and carefully ignite. If the amount of nickel and cobalt is small it can be weighed as oxides. However, if there is an appreciable amount of residue after ignition, dissolve by boiling with 10 cc. of aqua regia, wash into a 250-cc. beaker, add 10 cc. of H_2SO_4 (1:1), evaporate until fumes appear, cool, dilute to 200 cc., make alkaline with ammonia, and add 15 cc. of concentrated ammonia. Then electrolyze the solution and weigh the nickel and cobalt as such.

If the filtrate from the nickel and cobalt sulfides shows a brown color, it indicates that the precipitation has not been complete. In this case render the solution ammoniacal and repeat the above process.

DETERMINATION OF MANGANESE.

Evaporate the filtrate, which should now contain only manganese, to dryness in a porcelain dish and heat carefully over an Argand burner until all the ammonium salts have been driven off. It is best to bake here over a Bunsen flame until all the organic matter has been destroyed. After cooling, moisten the residue with a little HCl and warm until dissolved. Add 1 cc. of H_2SO_4 (1:1) and evaporate the solution until fumes appear, continuing the fuming until nearly all the H_2SO_4 has been driven off. Cool, and add 50 cc. of HNO_3 (1:3) and 0.5 g. of sodium bismuthate. The HNO_3 must be freed from nitrous fumes, by passing a current of air through the acid for $\frac{1}{2}$ hour. Boil the solution until the pink color is destroyed. If any manganese is precipitated, dissolve by the addition of a few cubic centimeters of a dilute sodium thiosulfate solution. In this case the solution must be again boiled until freed from all fumes. After cooling, add an excess of sodium bismuthate, stir a few minutes and filter through ignited asbestos into a 100-cc. Nessler tube. Wash with dilute HNO_3 (300 cc. to 1000 cc. of water) and make the filtrate up to the mark. Into another similar tube put 100 cc. of dilute H_2SO_4 (25 cc. to 1000 cc. of water) which has been made very faintly pink with potassium permanganate solution. Now add a standard solution of potassium permanganate from a burette until the color of the sample is exactly matched. The standard solution of permanganate should be made up as required by diluting 10 cc. of N/10 permanganate to 100 cc. of water. Each 1 cc. of standard permanganate solution = 0.00011 g. of manganese.

NOTES ON THE ANALYSIS.

When separating the sulfides of arsenic, antimony and tin from the sulfides of copper, lead, etc., it is necessary to wash all the sulfides back into the beaker in which they were precipitated. These sulfides sometimes cling so tenaciously to the paper that in dislodging them more water than the 25 cc. specified will be required. In this case allow the sulfides to settle and then decant the clear supernatant liquor through the filter until the volume is reduced to 25 cc. Before rejecting the decanted fluid always test with H_2S water.

In washing sulfide precipitates with water, much trouble is experienced from the tendency of the precipitate to pass through the filter in the colloidal form. This is particularly true in washing sulfides that have been digested with KOH. Time and trouble will be saved by washing all the sulfides precipitated from mineral acid solutions with H_2S water containing a little of the acid in which they were precipitated. The same is true of sulfides precipitated in or filtered from alkaline solution.

When working with alkaline solutions in which tin is to be determined, avoid the use of Jena or other glass that contains zinc. The zinc content of the glass may influence the result.

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INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS AND TESTS FOR COMPRESSIVE STRENGTH OF PORTLAND-CEMENT MORTARS.[1]

Serial Designation: C 9 – 16 T.

These specifications and tests are issued under the fixed designation C 9; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916.

SPECIFICATIONS.

Compressive Strength.

1. The average compressive strength in pounds per square inch of not less than three standard mortar test pieces (see Section 4) composed of one part cement and three parts standard sand, by weight, shall be equal to or higher than the following:

Age at Test, days.	Storage of Test Pieces.	Compressive Strength, lb. per sq. in.
7	1 day in moist air, 6 days in water........................	1200
28	1 day in moist air, 27 days in water......................	2000

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[1] Criticisms of these Tentative Specifications and Tests are solicited and should be directed, preferably before January 1, 1920, to Mr. P. H. Bates, Secretary of Committee C-1 on Cement, Bureau of Standards, Washington, D. C.

These specifications and tests, when adopted as standard, will be added to the present Standard Specifications and Tests for Portland Cement (Serial Designation: C 9–17), 1918 Book of A.S.T.M. Standards.

Strength at 28 Days. 2. The average compressive strength of standard mortar at 28 days shall be higher than the strength at 7 days.

TESTS.

Mixing Standard Mortar. 3. The requirements governing the preparation of standard sand mortars for tension test pieces shall apply to compression test pieces.[1]

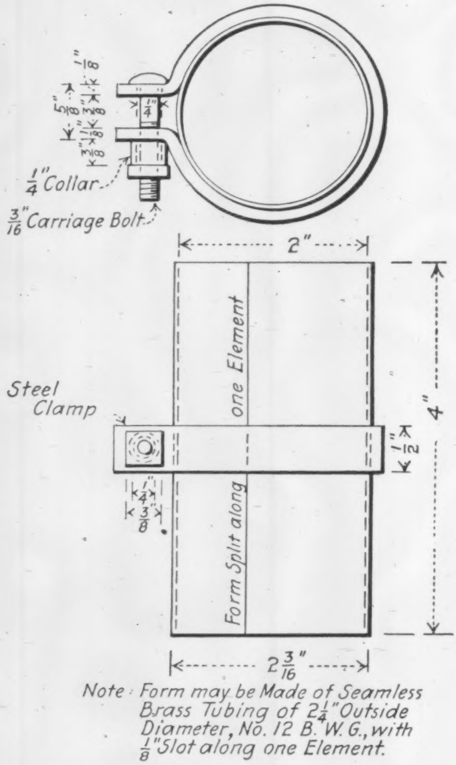
1/8"
5/8"
3/8"
1/8"
3/8"
1/4"
1/4" Collar
3/16" Carriage Bolt
2"
4"
Steel Clamp
Form Split along one Element
1/2"
1/4"
3/8"
2 3/16"
Note: Form may be Made of Seamless Brass Tubing of 2 1/4" Outside Diameter, No. 12 B. W. G., with 1/8" Slot along one Element.

FIG. 1.—Details for 2 by 4-in. Cylinder Form.

Form of Test Piece. 4. A cylindrical test piece 2 in. in diameter and 4 in. in length is recommended for use in making compression tests of standards mortars. The molds shall be made of non-corroding metal. A satisfactory form of mold is shown in Fig. 1. The ends of the mold shall be parallel. The tubing used in the molds shall be of sufficient thickness to prevent appreciable distortion. The molds shall be oiled before using. During the molding of the test piece, the mold shall rest on a clean, plane surface (preferably a piece of plate glass which is allowed to remain in place until the mold is removed).

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[1] See Standard Specifications and Tests for Portland Cement (Serial Designation: C 9), 1918 Book of A.S.T.M. Standards.

Molding.

5. The mortar[1] shall be placed in the mold in layers about 1 in. in thickness, each layer being tamped by means of the steel tamper shown in Fig. 2. The weight of tamper shall be approximately ¾ lb. In finishing the test piece, the mortar shall be heaped above the mold and smoothed off with a trowel. As soon as the test pieces from one sample are molded, the top of each test piece shall be covered with a piece of glass which is brought to a firm bearing on the fresh mortar. The cover glasses shall remain in place until the molds are removed.

Storage.

6. The compression test pieces shall be stored in the same manner as the tension test pieces.

Testing.

7. Tests of standard-mortar cylinders shall be made in any testing machine which is adapted to meet the specified requirements. The test pieces shall be tested as soon as removed from the water. The ends of the test cylinders shall be smooth, plane surfaces. The metal bearing plates of the testing machine shall be placed in direct contact with the ends of the test piece. During the test a spherical bearing block shall be used on top of the cylinder. In order to secure a uniform distribution of the load over the test cylinder the spherical bearing block must be accurately centered. The diameter of the spherical bearing block should be only a little greater than that of the test piece. The test piece shall be loaded continuously to failure. The moving head of the testing machine shall travel at the rate of not less than 0.05 or more than 0.10 in. per minute.

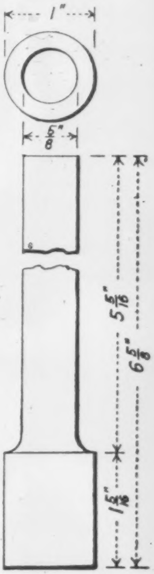

FIG. 2.—Details for Steel Tamper.

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[1] If sufficient mortar for six 2 by 4-in. cylinders is to be mixed in a single batch, approximately 3000 g. of material will be required. In this case the mixing shall be continued for 1½ minutes.

Calibration. 8. Testing machines should be frequently calibrated in order to determine their accuracy.

Faulty Cylinders. 9. Cylinders that are manifestly faulty, or which give strengths differing more than 15 per cent from the average value of all test pieces tested at the same period and made from the same sample, shall not be considered in determining the compressive strength.

AMERICAN SOCIETY FOR TESTING MATERIALS

PHILADELPHIA, PA., U. S. A.

AFFILIATED WITH THE

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS[1]
FOR
BUILDING BRICKS.[1]

Serial Designation: C 21 - 19 T.

These specifications are issued under the fixed designation C 21; the final number indicates the year of original issue, or in the case of revision the year of the last revision.

ISSUED, 1919.

I. STANDARD SIZE.

Standard Size.

1. The standard size of building brick shall be $2\frac{1}{4}$ by $3\frac{7}{8}$ by 8 in.

II. SAMPLING.

Sampling.

2. For the purpose of tests, bricks shall be selected by an experienced person so as to represent the commercial product. All bricks shall be carefully examined and their condition noted before being subjected to any kind of test. For the purpose of the tests ten bricks will be required; they shall be thoroughly dried to constant weight in a suitable oven at a temperature of from 225° F. (107° C.) to 250° F. (121° C.).

III. PHYSICAL TESTS.

Absorption.

3. (*a*) At least five dry bricks shall be weighed and completely submerged in water at a temperature between 60 and 80° F., the water heated to boiling within one hour, boiled

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferable before January 1, 1920, to Mr. A. V. Bleininger, Secretary of Committee C-3 on Brick, Bureau of Standards, Pittsburgh, Pa.

continuously for five hours and then allowed to cool in the water to a temperature between 60 and 80° F. They shall then be removed, the surface water wiped off with a damp cloth and the brick quickly weighed.

(*b*) The percentage of absorption shall be computed on the dry weight, according to the relation:

$$\text{Percentage of Absorption} = \frac{100\ (B - A)}{A},$$

where A = weight of dry brick and B = weight of saturated brick.

Compression Tests.

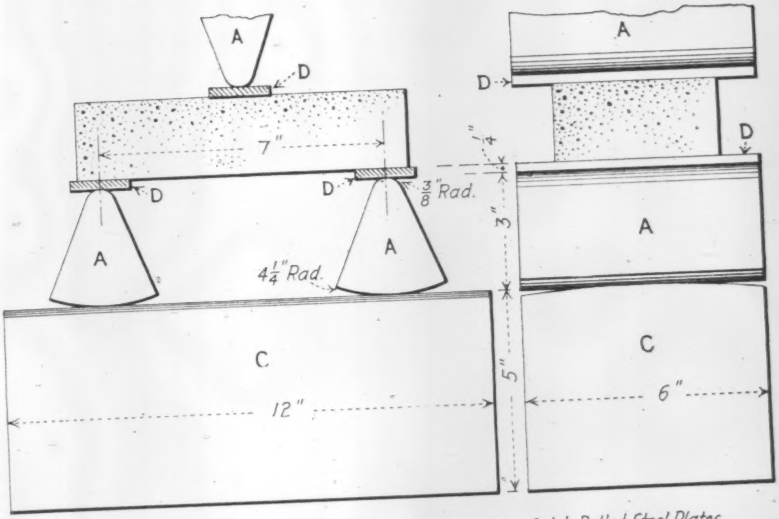
4. (*a*) Compression tests shall be made on at least five half bricks, previously dried, each taken from a different brick. The half brick shall be prepared either by sawing or cutting upon a yielding bed with a sharp mason's chisel, which shall be the full width of the brick. The specimens shall be tested on edge. To secure a uniform bearing in the testing machine the edge surfaces shall be bedded in a thin coat of plaster of Paris spread upon plate glass previously coated with a film of oil. Before applying the plaster of Paris, the bearing surface of the brick shall receive a coating of shellac. The brick shall be pressed firmly upon the surface, making the layer as thin as possible, and remain undisturbed until set. The depression of recessed or paneled bricks shall be filled with neat Portland-cement mortar, which shall stand at least 24 hours before testing.

(*b*) The machine used for the compression tests shall be equipped with a spherical bearing block kept thoroughly lubricated to insure accurate adjustment, which should be made by hand under a small initial load. During the test the beam of the testing machine shall be kept constantly in a floating position.

(*c*) The breaking load shall be divided by the area in compression and the results reported in pounds per square inch.

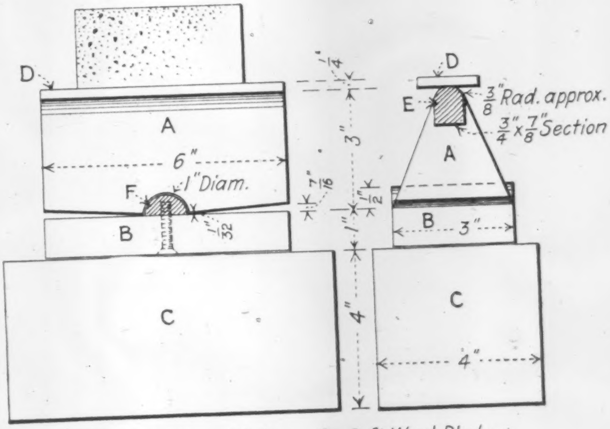
Transverse Tests.

5. (*a*) At least five bricks, previously dried, shall be tested, laid flat-wise, with a span of 7 in., and with the load applied at midspan. The knife edges shall be slightly curved in the direction of their length. Steel bearing plates, about $\frac{1}{4}$ in. thick by $1\frac{1}{2}$ in. wide, may be placed between the knife edges and the brick. The use of a wooden base block, slightly rounded transversely across its top, upon which to rest the lower knife


A
D
7"
1/4"
D
D
3/8" Rad.
A
A
4 1/4" Rad.
A
3"
D
A
C
12"
5"
C
6"

A = Cast-Iron Wedges; C = Soft Wood Block; D = Cold-Rolled Steel Plates.

FIG. 1.


D
1/4"
D
3/8" Rad. approx.
E
3/4" x 7/8" Section
A
3"
A
6"
F
1" Diam.
7/16"
1/2"
B
1/32"
1"
B
3"
C
4"
C
4"

A, B = Cast-Iron Wedges; C = Soft Wood Block;
D, E, F = Cold-Rolled Steel.

FIG. 2.

LABORATORY RECORD.

The Engineering Laboratory of..

Brick received from..

Address..

Sampled by...................................... Date......................................

Type...................................... Class (A.S.T.M.)......................................

Appearance of bricks..

ABSORPTION TEST.

Sample No.	Weight.			Absorption, per cent $\frac{B-A}{A} \times 100$	Remarks.
	Dry (A)	Saturated (B)	Difference $(B-A)$		
1					
2					
3					
4					
5					
Sum......					
Average......					

COMPRESSION TEST.

(HALF BRICKS TESTED ON EDGE.)

Sample No.	Dimensions of half brick.			Load		Compressive Strength, $\left(\frac{L}{a}\right)$ lb. per sq. in.	Remarks.
	Depth (d), in.	Length (l), in.	Area (a) $a=dl$	At First Crack, lb.	At Failure (L), lb.		
1							
2							
3							
4							
5							
Sum........							
Average.....							

TRANSVERSE TEST.

Sample No.	Dimensions.			Load (W), lb.	Modulus of Rupture $R=\frac{3Wl}{2bd^2}$	Remarks.
	Width (b), in.	Depth (d), in.	Span (l), in.			
1						
2						
3						
4						
5						
Sum........						
Average.....						

SUMMARY.

Average Absorption, per cent.	Average Compressive Strength, lb. per sq. in.	Average Modulus of Rupture.

Observers:

....

....

....

In charge of tests.

edges (see Fig. 1), or the form of lower knife edge shown in Fig. 2, is recommended. If the knife edges shown in Fig. 2 are used, they should rest upon smooth plane blocks of wood at least 2 in. thick.

(*b*) The modulus of rupture shall be computed in pounds per square inch by the following formula:

$$R = \frac{3\ Wl}{2\ bd^2},$$

in which l = the distance between supports in inches, b = the breadth and d = depth of the brick in inches, and W = the load in pounds at which the brick failed.

Record of Test Results.

6. In recording the results of the test the type of brick shall be defined, whether stiff mud, soft mud, dry pressed, repressed, sand lime or other types. It is recommended that the data obtained be recorded as indicated on the accompanying "Laboratory Record."

IV. CLASSIFICATION OF BRICKS.

Classification of Bricks.

7. (*a*) According to the results of the physical tests, the bricks shall be classified as vitrified, hard, medium and soft bricks on the basis of the following requirements:

Name of Grade.	Absorption Limits, per cent.		Compressive Strength (on edge), lb. per sq. in.		Modulus of Rupture, lb. per sq. in.	
	Mean of 5 Tests.	Individual Maximum.	Mean of 5 Tests.	Individual Minimum.	Mean of 5 Tests.	Individual Minimum.
Vitrified Brick.	5 or less	6.0	5000 or over	4000	1200 or over	800
Hard Brick....	5 to 12	15.0	3500 or over	2500	600 or over	400
Medium Brick.	12 to 20	24.0	2000 or over	1500	450 or over	300
Soft Brick.....	20 or over	No limit	1000 or over	800	300 or over	200

(*b*) The standing of any set of bricks shall be determined by that one of the three requirements in which it is lowest.

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PHILADELPHIA, PA., U. S. A.
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INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS
FOR
CLAY SEWER PIPE.[1]

Serial Designation: C 13 - 18 T.

These specifications are issued under the fixed designation C 13; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917; REVISED, 1918.

Material Covered.

1. These specifications cover clay products intended to be used for the conveyance of sewage, industrial wastes and storm water.

Single Class.

2. Sewer pipes furnished under these specifications shall be of a single class to be designated "A.S.T.M. Clay Sewer Pipe."

I. MATERIAL AND MANUFACTURE.

Materials.

3. (*a*) Clay pipes shall be manufactured from clay, fire clay or shale, or a combination of these materials.

(*b*) *Clay.*—Clay is intended to mean red burning plastic clay devoid of fissile fracture with maturing temperature about 1170° C. (2138° F.).

(*c*) *Fire Clay.*—Fire clay is intended to mean buff, gray or reddish burning fire clay showing conchoidal structure, with maturing temperature about 1250° C. (2282° F.).

(*d*) *Shale.*—Shale is intended to mean red burning hard clay with a distinct fissile fracture and vitrifying at from 1050 to 1250° C. (1922 to 2280° F.).

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. Rudolph Hering, Chairman of Committee C-4 on Clay and Cement Sewer Pipe, 170 Broadway, New York City.

(*e*) The materials shall possess such physical and chemical properties that when molded into pipes and subjected to a suitable temperature the product will be strong, durable and serviceable, free from objectionable defects, and in compliance with these specifications and tests.

II. CHEMICAL TESTS AND REQUIREMENTS.

Chemical Tests. and Requirements.

4. The consumer or purchaser may prescribe in advance special chemical requirements in cases where industrial wastes have marked acid or alkaline character, or are of abnormally high temperatures. He may make use of chemical analysis of the pipe material to ascertain whether these special requirements are met. The presence of visible grains or masses of caustic lime, iron pyrites or any other materials which cause slaking or disintegration shall be a cause for rejection.

III. PHYSICAL TESTS.

Physical Tests.

5. The physical tests of pipes shall include: crushing test, hydrostatic pressure test, and absorption test.[1]

Test Specimens.

6. The specimens to be tested shall be selected by the purchaser or his representative at the point or points designated by him when placing the order. The manufacturer or seller shall furnish specimens for test, without separate charge, up to 1 per cent of the number of pipes to be delivered or furnished in each size of pipe. The minimum number of specimens for any delivery less than 200 pieces shall be two specimens in each size of pipe.

Acceptance or Rejection on Result of Tests.

7. Failure of 20 per cent of the specimens to meet the requirements of any of the tests imposed, shall result in rejection of all the pipe in the shipment or delivery, corresponding to the sizes thus failing to comply; except that in the event of 20 per cent of the specimens in any size failing to meet the requirements, the manufacturer or seller may, with the consent of the consumer or purchaser, furnish for test additional specimens from the same shipment without charge. In case more than 80 per cent of the specimens tested, including those first tested, shall show substantial compliance for each of the various tests

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[1] Committee C-4 will prepare a specification also for an abrasion test.

TABLE I.—DIMENSIONS, ETC., OF CLAY SEWER PIPE FURNISHED AS TEST SPECIMENS.

Specimen No.	Date.	Job No.	Material.	Manufacturer.	Location of Factory.	Nominal Size, in.	Weight, lb.	Length, ft.	Thickness of Spigot, in.				Thickness of Socket, in.				Internal Diameter, in.						Remarks.
																	Spigot.		Back of Socket.		Socket.		
									Invert.	Crown.	Side.	Side.	Invert.	Crown.	Side.	Side.	Vertical.	Horizontal.	Vertical.	Horizontal.	Vertical.	Horizontal.	

performed, then the entire shipment or delivery for this size shall be accepted; otherwise it shall be rejected.

Measurement and Observation of Specimens.

8. The specimens of pipes shall be sound, full-size pipe. They shall first be freed from all visible moisture. When dry each specimen shall be weighed, measured and inspected. The results of these observations shall be recorded and preserved as shown in Table I.

Rejection of Defective Specimens.

9. Specimens which, when placed in a vertical position, do not give a metallic ring when struck with a hammer, or are observed to have fire cracks or other defects in form or dimensions in excess of the limits permitted in these specifications, shall be discarded and replaced with additional specimens from the shipment.

(*A*) *Crushing Tests.*

Application of Load.

10. (*a*) Any prime mover or hand power which will apply the load at a uniform rate of about 2000 lb. per minute, or in increments of not more than 100 lb. at the same rate, may be used in making the test.

(*b*) The pipe shall not be allowed to stand under load longer than is required to apply the load and to observe and record it.

(*c*) The testing machine shall be substantial and rigid throughout, so that the distribution of the load will not be affected appreciably by the deformation or yielding of any part.

(*d*) The bearings and the specimen shall be accurately centered so as to secure a symmetrical distribution of the loading on each side of the center of the pipe in every direction.

(*e*) The load shall be applied until the pipe yields by cracks passing through the shell.

Knife or Two-Edge Bearings.

11. (See Fig. 1, Plate VI.).—Except as otherwise hereinafter specified, the pipe to be tested shall be supported by a metallic knife bearing 1 in. wide and extended from a point just back of the socket to the spigot end of the pipe. Before the pipe is placed a fillet of plaster of Paris and sand 1 in. wide, and thick enough to compensate for all the inequalities of the pipe barrel, shall be cast on the surface of the knife-edge bearing. The pipe shall be placed upon the fillet while the plaster of Paris is still somewhat plastic. The load shall be applied through an upper knife bearing of the same size and length as the lower bearing.

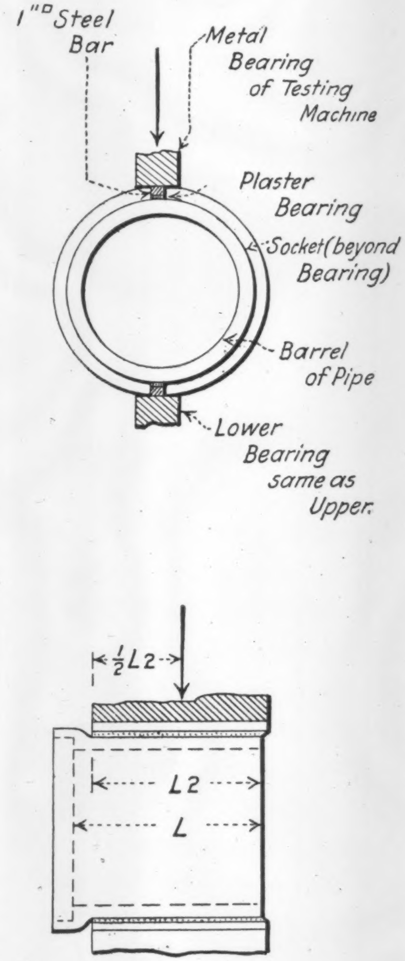
1"□ Steel Bar
Metal Bearing of Testing Machine
Plaster Bearing
Socket (beyond Bearing)
Barrel of Pipe
Lower Bearing same as Upper.
½L2
L2
L

FIG. 1.—Knife or Two-Edge Bearings.

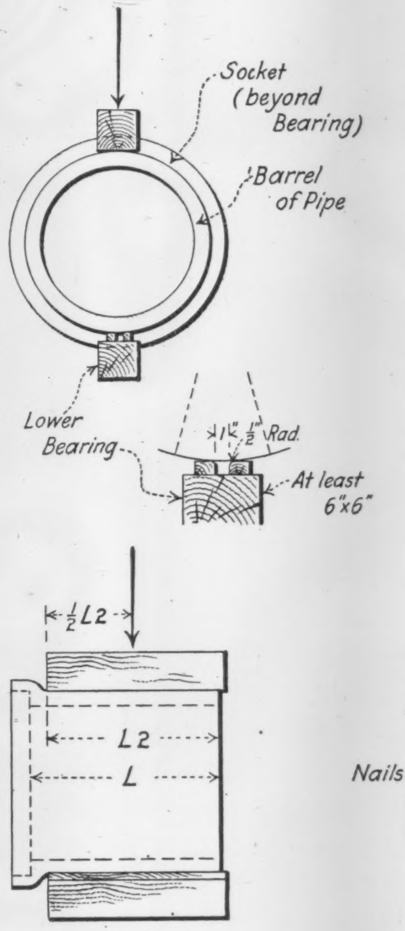
Socket (beyond Bearing)
Barrel of Pipe
Lower Bearing
1" ½" Rad.
Lower Bearing
At least 6"x6"
½L2
L2
L

FIG. 2.—Three-Edge Bearings.

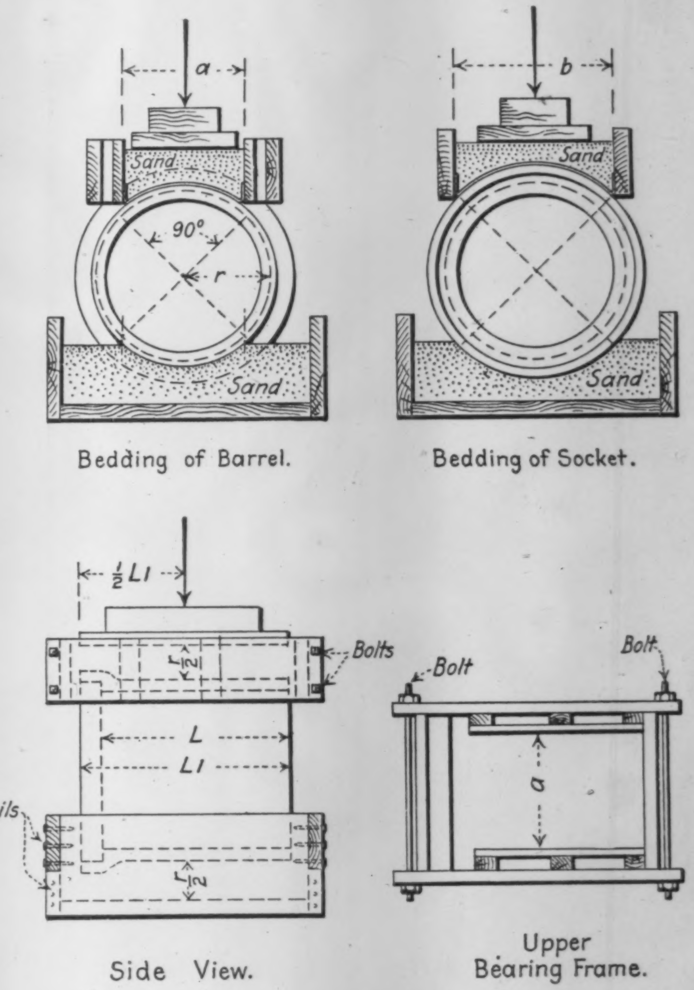
a
Sand
90°
r
Sand
Bedding of Barrel.
b
Sand
Sand
Bedding of Socket.
½L1
Bolts
r/2
L
L1
Nails
r/2
Side View.
Bolt
Bolt
a
Upper Bearing Frame.

FIG. 3.—Sand Bearings.

A plaster-of-Paris filet 1 in. wide shall be cast along the length of the crown of the pipe to equalize the lower bearing before the upper one is brought into contact.

Both of the bearings shall be sufficiently rigid to transmit and receive uniform loads throughout their lengths without deflection, and shall be so attached to the machine as to transmit and receive the maximum stresses produced by the tests without lost motion, vibration or sudden shock.

At the option of the consumer or purchaser the crushing test may be applied with sand bearings or with two or three-edge bearings.

The crushing strength shall be calculated by dividing the total load required to break each pipe by the net inside length of the barrel of the pipe, measuring from the bottom of the socket to the end of the spigot; and by then multiplying the quotient by the following factors:

For knife or two-edge bearings	$\frac{10}{7}$
" three-edge bearings	$\frac{10}{7}$
" sand bearings	1.00

Three-Edge Bearings.

12. (See Fig. 2, Plate VI.).—When three-edge bearings are used, the ends of each specimen of pipe shall be accurately marked in halves of the circumference prior to the test.

The two lower bearings shall consist of two wooden strips with vertical sides, each strip having its interior top corner rounded to a radius of approximately $\frac{1}{2}$ in. They shall be straight, and shall be securely fastened to a rigid block with their interior vertical sides 1 in. apart.

The upper bearing shall be a wooden block, straight and true from end to end.

The test load shall be applied through the upper bearing block in such a way as to leave the bearing free to move in a vertical plane passing midway between the lower bearings.

In testing a pipe which is "out of straight," the lines of the bearings chosen shall be from those which appear to give most favorable conditions for fair bearings.

Sand Bearings.

13. (See Fig. 3, Plate VI.).—When sand bearings are used, the ends of each specimen of pipe shall be accurately marked prior to the test in quarters of the circumference. Specimens

shall be carefully bedded, above and below, in sand, for one-fourth the circumference of the pipe measured on the middle line of the barrel. The depth of bedding above and below the pipe at the thinnest points shall be one-half the radius of the middle line of the barrel.

The sand used shall be clean, and shall be such as will pass a No. 4 screen.

The top bearing frame shall not be allowed to come in contact with the pipe nor with the top bearing plate. The upper surface of the sand in the top bearing shall be struck level with a straight edge, and shall be covered with a rigid top bearing plate, with lower surface a true plane, made of heavy timbers or other rigid material, capable of distributing the test load uniformly without appreciable bending. The test load shall be applied at the exact center of this top bearing plate, in such a manner as to permit free motion of the plate in all directions. For this purpose a spherical bearing is preferred, but two rollers at right angles may be used. The test may be made without the use of a testing machine, by piling weights directly on a platform resting on the top bearing plate, provided, however, that the weights shall be piled symmetrically about a vertical line through the center of the pipe, and that the platform shall not be allowed to touch the top bearing frame.

The frames of the top and bottom bearings shall be made of timbers so heavy as to avoid appreciable bending by the side pressure of sand. The interior surfaces of the frames shall be dressed. No frame shall come in contact with the pipe during the test. A strip of cloth may, if desired, be attached to the inside of the upper frame on each side, along the lower edge, to prevent the escape of sand between the frame and the pipe.

Number of Specimens.

14. The crushing test shall ordinarily be applied to not less than 75 per cent of the specimens received for testing purposes.

Specimens for Absorption Test.

15. Pieces of the crushed pipe may be used as specimens in making the absorption test.

(*B*) *Hydrostatic Test.*

Hydrostatic Test.

16. Sound full-size pipe not exceeding about 25 per cent of the specimens received for test in each size of pipe, shall be tested for leakage under internal hydrostatic pressure.

The ends of the pipe shall be tightly closed by wooden or metallic bulkheads or covers faced with rubber or leather so that no leakage shall occur through the covers at the test pressure. One cover shall be provided with a $\frac{3}{4}$-in. wrought-iron nipple passing through the cover, and held securely in place and made water-tight by means of locknuts and washers or gaskets. The outer end of the nipple shall be connected with a pump discharge or water service line.

Water pressure of 5 lb. per sq. in., as measured by a standardized gage attached to the delivery pipe close to the specimen, shall be internally applied to the specimen for 5 minutes. At the end of this period the water pressure shall be raised to 15 lb. per sq. in. and maintained for a period of 15 minutes.

The quantity of water passing through the barrel of the specimen at 15 lb. per sq. in. shall be collected and measured at the end of the test. The result shall be reported as percolation in gallons per mile in 24 hours.

(*C*) *Absorption Test.*

Test Specimens.

17. The specimens shall be sound pieces, with all edges broken, and may be from pipes broken in the crushing or other tests. They shall be from 12 to 20 sq. in. in area, and shall be as nearly square as they can be readily prepared. They shall be free from observable cracks, fissures, laminations or shattered edges.

Drying.

18. Preparatory to the absorption test, the specimen shall be first weighed and then dried in a drier or oven at a temperature of not less than 110° C. (230° F.) for not less than three hours. After removal from the drier, the specimen shall be allowed to cool in dry air to a temperature of 20 to 25° C. (68 to 77° F.), and then reweighed.

If the specimen is comparatively dry when taken, and the second weight closely agrees with the first, it shall be considered dry. If the specimen is wet when taken it shall be placed in the drier for a drying treatment of two hours and reweighed. If the third weight checks the second the specimen shall be considered dry. In case of any doubt, the specimen shall be redried for two-hour periods, until check weights are obtained.

Weighing. 19. The balance used shall be sensitive to 0.5 g. when loaded with 1 kg., and weighings shall be read to the nearest gram. When other than metric weights are used, the same degree of accuracy shall be obtained.

Immersion. 20. The specimen, after final drying, cooling and weighing, shall be placed with other similar specimens in a suitable wire receptacle, packed tightly enough to prevent jostling, covered with distilled water or rainwater, raised to the boiling point and boiled for five hours, and then cooled in water to a final temperature of 10 to 15° C. (50 to 59° F.).

Reweighing. 21. The specimen shall be allowed to drain for one minute, and, the superficial moisture having been removed by towel or blotting paper, placed upon the balance.

Calculation of Absorption. 22. The test result shall be calculated as percentage of the initial dry weight.

Number of Specimens. 23. One specimen shall be tested of each pipe broken in the crushing test.

Reporting Results. 24. The results shall be reported separately for each individual specimen, together with the mean for all the specimens from the same shipment of pipe.

Identification. 25. Each specimen shall be marked so that it may be identified with the pipe used in the crushing test from which the specimen was taken. The marking shall be applied so that the pigment used shall not cover more than 1 per cent of the total superficial area of the specimen.

IV. PHYSICAL TEST REQUIREMENTS.

Physical Requirements. 26. The test requirements of clay sewer pipe shall be as given in Table II. The individual results of the various tests for each size of pipe and for each shipment class and mill shall be tabulated separately so as to show the percentage which fails to comply with the requirements of each test.

V. A.S.T.M. SIZES AND DIMENSIONS.

Sizes and Dimensions. 27. Pipes shall be furnished of the sizes, internal diameter, and with the minimum dimensions given in Table III. Where several lengths are mentioned in the table the consumer or purchaser shall indicate, at the time of purchase, which lengths shall be furnished; and unless so indicated, the manufacturer shall furnish such lengths as he may elect.

Permissible Variations.

28. The permissible variation from the dimensions given in Table III shall not exceed those stated in Table IV. Where the thickness of barrel is increased beyond that given in Table IV in order to meet the specified requirements of strength, the diameter at inside of socket shall be increased by double the increase in thickness of barrel. Pipes intended to be straight shall not have variation in alignment of more than $\frac{1}{8}$ in. per foot of length.

TABLE II.—PHYSICAL TEST REQUIREMENTS OF CLAY SEWER PIPE.

Internal Diameter, in.	Minimum Crushing Strength,[1] lb. per lin. ft.	Maximum Percolation, gal. per mile in 24 hr.	Maximum Absorption, per cent.
6	1430	These requirements will be furnished later.	These requirements will be furnished later.
8	1430		
10	1570		
12	1710		
15	1960		
18	2200		
21	2590		
24	3070		
27	3370		
30	3690		
33	3930		
36	4400		
39	4710		
42	5030		

[1] See end of Section 11.

VI. WORKMANSHIP AND FINISH.

Absence of Defects.

29. Pipes shall be substantially free from fractures, large or deep cracks and blisters, laminations and surface roughness.

Scored Ends.

30. The inner surface of the socket and the outer surface of the spigot end shall be scored by triangular shaped or semicircular shaped rings about $\frac{1}{8}$ in. deep.

The number of scorings shall be as follows:

For pipes 6 to 10 in. in diameter, inclusive	2
" " 12 " 21 " " " "	3
" " 24 " 30 " " " "	4
" " 33 " 42 " " " "	5

Salt Glaze. 31. The glaze shall consist of a continuous layer of bright or semi-bright glass substantially free from coarse blisters and pimples. If present none of these shall project more than $\frac{1}{8}$ in. above the surrounding surface. Not more than 10 per cent of the inner surface of any pipe barrel shall be bare of glaze except the socket, where it may be entirely absent. Glazing will not be required on the outer surface of the barrel at the spigot end for a distance from the end equal to two-thirds the specified depth of socket for the corresponding size of pipe. Where glazing is required there shall be absence of any well-defined net work of crazing lines or hair cracks. All glazing shall be equal to that produced by the best salt-glazing process.

TABLE III.—DIMENSIONS OF CLAY SEWER PIPE.

Internal Diameter, in.	Laying Length, ft.	Diameter at Inside of Socket, in.[1]	Depth of Socket, in.	Taper of Socket.	Thickness of Barrel, in.
6	2	$8\frac{1}{4}$	2	1 : 20	$\frac{5}{8}$
8	2, $2\frac{1}{2}$, 3	$10\frac{3}{4}$	$2\frac{1}{4}$	1 : 20	$\frac{3}{4}$
10	2, $2\frac{1}{2}$, 3	13	$2\frac{1}{2}$	1 : 20	$\frac{7}{8}$
12	2, $2\frac{1}{2}$, 3	$15\frac{1}{4}$	$2\frac{1}{2}$	1 : 20	1
15	2, $2\frac{1}{2}$, 3	$18\frac{3}{4}$	$2\frac{1}{2}$	1 : 20	$1\frac{1}{4}$
18	2, $2\frac{1}{2}$, 3	$22\frac{1}{4}$	3	1 : 20	$1\frac{1}{2}$
21	2, $2\frac{1}{2}$, 3	26	3	1 : 20	$1\frac{3}{4}$
24	2, $2\frac{1}{2}$, 3	$29\frac{1}{2}$	3	1 : 20	2
27	3	$33\frac{1}{4}$	$3\frac{1}{2}$	1 : 20	$2\frac{1}{4}$
30	3	37	$3\frac{1}{2}$	1 : 20	$2\frac{1}{2}$
33	3	$40\frac{1}{4}$	4	1 : 20	$2\frac{5}{8}$
36	3	44	4	1 : 20	$2\frac{3}{4}$
39	3	$47\frac{1}{4}$	4	1 : 20	$2\frac{7}{8}$
42	3	51	4	1 : 20	3

[1] When pipes are furnished having an increase in thickness over that given in last column, the diameter of socket shall be increased by an amount equal to twice the increase of thickness of barrel.

Finish of Ends. 32. The ends of the pipes shall be square with their longitudinal axis, except as provided in Table IV.

Specials. 33. (*a*) Special shapes shall have a plain spigot end and a socket end corresponding in all respects with the dimensions specified for pipes of the corresponding internal diameter. Branch pipes shall be furnished to lay the same lengths as straight pipe.

All specials shall conform in finish to the specifications for pipes given in Sections 29, 30, 31 and 32.

(*b*) Slants shall have their spigot ends cut at an angle of approximately 45 deg. with the longitudinal axis.

(*c*) Curves shall be at angles of 90, 45, $22\frac{1}{2}$ deg., as required. They shall conform substantially to the curvature specified.

(*d*) Branches shall be furnished with the connection or connections of the size or sizes specified, securely and completely fastened by fusion in the process of vitrification to the barrel of the pipe. T-branches and double T-branches shall have the axis perpendicular to the longitudinal axis of the pipe. Y-branches, double Y-branches, and V-branches shall have their axes approximately 45 deg. from the longitudinal axis of the pipe measured from the socket end. All branches shall terminate in sockets and the barrel of the branch shall be of sufficient length

TABLE IV.—PERMISSIBLE VARIATIONS IN DIMENSIONS OF CLAY SEWER PIPE.

Normal Size in.	Limits of Permissible Variation in:					
	Length, in. per ft. (−)	Lengths of Two Opposite Sides, in.	Internal Diameter, in.		Depth of Socket, in. (−)	Thickness of Barrel, in. (−)
			Spigot (±)	Socket (±)		
6	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{16}$
8	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{1}{16}$
10	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{1}{16}$
12	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{1}{16}$
15	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{3}{32}$
18	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{4}$	$\frac{3}{32}$
21	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{8}$
24	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{1}{4}$	$\frac{1}{8}$
27	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{1}{4}$	$\frac{1}{8}$
30	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{1}{4}$	$\frac{1}{8}$
33	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{1}{4}$	$\frac{3}{16}$
36	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{1}{4}$	$\frac{3}{16}$
39	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{1}{4}$	$\frac{3}{16}$
42	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{1}{4}$	$\frac{3}{16}$

NOTE.—The minus sign (−) alone indicates that the plus variation is not limited ; the plus and minus sign (±) indicates variation in both excess and deficiency in dimension.

to permit making a proper joint when the connecting pipe is inserted in the branch socket.

(*e*) Channel or split pipes, curves and branches shall be accurate half sections of the corresponding size of straight pipe and specials.

VII. MARKINGS.

Markings

34. Pipes shall bear the initials or name of the person, company or corporation by whom they are manufactured, and the location of the mill. The markings shall be indented on the exterior of the barrel near the socket and shall be plainly legible for purpose of identification.

VIII. INSPECTION.

Inspection.

35. All pipes shall be subject to inspection at the factory, trench or other point of delivery by a competent inspector employed by the consumer or purchaser. The purposes of the inspection shall be to cull and reject pipes which, independent of the physical tests herein specified, fail to comply with the requirements of these specifications.

Rejection.

36. Pipes shall be subject to rejection on account of the following:

(*a*) Variations in any dimension exceeding the permissible variations given in Table IV.

(*b*) Fracture or cracks passing through the shell or socket, except that a single crack at either end of a pipe not exceeding 2 in. in length or a single fracture in the socket not exceeding 3 in. in width nor 2 in. in length will not be deemed cause for rejection unless these defects exist in more than 5 per cent of the entire shipment or delivery.

(*c*) Blisters where the glazing is broken or which exceed 3 in. in diameter, or which project more than $\frac{1}{8}$ in. above the surface.

(*d*) Laminations which indicate extended voids in the pipe material.

(*e*) Fire cracks or hair cracks sufficient to impair the strength, durability or serviceability of the pipe.

(*f*) Variation of more than $\frac{1}{8}$ in. per linear foot in alignment of a pipe intended to be straight.

(*g*) Glaze which does not fully cover and protect all parts of the shell and ends except those exempted in Section 31; also glaze which is not equal to best salt glaze.

(*h*) Failure to give a clear ringing sound when placed on end and dry-tapped with a light hammer.

(*i*) Insecure attachment of branches on spurs.

Marking of Rejected Specimens.

37. All rejected pipes shall be plainly marked by the inspector and shall be replaced by the manufacturer or seller with pipes which meet the requirements of these specifications, without additional cost to the consumer or purchaser.

AMERICAN SOCIETY FOR TESTING MATERIALS

PHILADELPHIA, PA., U. S. A.

AFFILIATED WITH THE

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS
FOR
CEMENT-CONCRETE SEWER PIPE.[1]

Serial Designation: C 14 – 19 T.

These specifications are issued under the fixed designation C 14; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917; REVISED, 1918, 1919.

Material Covered. 1. These specifications cover cement-concrete products intended to be used for the conveyance of sewage, industrial wastes and storm water.

Single Class. 2. Pipes furnished under these specifications shall be of a single class to be designated "A.S.T.M. Cement-Concrete Sewer Pipe."

I. MATERIAL AND MANUFACTURE.

Materials. 3. (*a*) Cement-concrete pipes shall be manufactured from Portland-cement concrete.

(*b*) *Concrete.*—By concrete is meant a suitable mixture of Portland cement, mineral aggregates and water, hardened by hydraulic chemical action.

(*c*) *Cement.*—Portland cement shall meet the requirements of the Standard Specifications and Tests for Portland Cement (Serial Designation: C 9)[1] of the American Society for Testing Materials.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. Rudolph Hering, Chairman of Committee C-4 on Clay and Cement Sewer Pipe, 170 Broadway, New York City.

(*d*) The materials shall possess such physical and chemical properties that when molded into pipes and properly cured the product will be strong, durable and serviceable, free from objectionable defects, and in compliance with these specifications and tests.

II. CHEMICAL TESTS AND REQUIREMENTS.

Chemical Tests and Requirements.

4. The consumer or purchaser may prescribe in advance special chemical requirements in cases where sewage, industrial wastes or ground waters have marked acid or alkaline character, or are of abnormally high temperatures. He may make use of chemical analysis of the pipe materials to ascertain whether these special requirements are met. The presence of deleterious materials causing slaking or disintegration shall be cause for rejection.

III. PHYSICAL TESTS.

Physical Tests.

5. The physical tests of pipes shall include: crushing test, hydrostatic pressure test and absorption test.[2]

Test Specimens.

6. The specimens to be tested shall be selected by the purchaser or his representative at the point or points designated by him when placing the order. The manufacturer or seller shall furnish specimens for test, without separate charge, up to 1 per cent of the number of pipes to be delivered or furnished in each size of pipe. The minimum number of specimens for any delivery less than 200 pieces shall be two specimens of each size of pipe.

Acceptance or Rejection on Result of Tests.

7. Failure of 20 per cent of the specimens to meet the requirements of any of the tests imposed, shall result in rejection of all the pipe in the shipment or delivery, corresponding to the sizes thus failing to comply; except that in the event of 20 per cent of the specimens in any size failing to meet the requirements, the manufacturer or seller may, with the consent of the consumer or purchaser, furnish for test additional specimens from the same shipment without charge. In case more than 80 per cent of the specimens tested, including those first tested,

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[1] 1918 Book of A.S.T.M. Standards.

[2] Committee C-4 will prepare a specification also for an abrasion test.

TABLE I.—DIMENSIONS, ETC., OF CEMENT-CONCRETE SEWER PIPE FURNISHED AS TEST SPECIMENS.

Specimen No.	Date.	Job No.	Material.	Manufacturer.	Location of Factory.	Nominal Size, in.	Weight, lb.	Length, ft.	Thickness of Spigot, in.				Thickness of Socket, in.				Internal Diameter, in.						Remarks.
																	Spigot.		Back of Socket.		Socket.		
									Invert.	Crown.	Side.	Side.	Invert.	Crown.	Side.	Side.	Vertical.	Horizontal.	Vertical.	Horizontal.	Vertical.	Horizontal.	

shall show substantial compliance for each of the various tests performed, then the entire shipment or delivery for this size shall be accepted; otherwise it shall be rejected.

Measurement and Observation of Specimens.

8. The specimens of pipes shall be sound, full-size pipe. They shall first be freed from all visible moisture. When dry each specimen shall be weighed, measured and inspected. The results of these observations shall be recorded and preserved as shown in Table I.

Rejection of Defective Specimens.

9. Specimens which, when placed in a vertical position, do not give a metallic ring when struck with a hammer, or are observed to have cracks or other defects in form or dimensions in excess of the limits permitted in these specifications, shall be discarded and replaced with additional specimens from the shipment.

(*A*) *Crushing Test.*

Application of Load.

10. (*a*) Any prime mover or hand power which will apply the load at a uniform rate of about 2000 lb. per minute, or in increments of not more than 100 lb. at the same rate, may be used in making the test.

(*b*) The pipe shall not be allowed to stand under load longer than is required to apply the load and to observe and record it.

(*c*) The testing machine shall be substantial and rigid throughout, so that the distribution of the load will not be affected appreciably by the deformation or yielding of any part.

(*d*) The bearings and the specimen shall be accurately centered so as to secure a symmetrical distribution of the loading on each side of the center of the pipe in every direction.

(*e*) The load shall be applied until the pipe yields by cracks passing through the shell.

Knife or Two-Edge Bearings.

11. (See Fig. 1, Plate VI.).[1]—Except as otherwise hereinafter specified, the pipe to be tested shall be supported by a metallic knife bearing 1 in. wide and extended from a point just back of the socket to the spigot end of the pipe. Before the pipe is placed a fillet of plaster of Paris and sand 1 in. wide, and thick enough to compensate for all the inequalities of the pipe barrel, shall be cast on the surface of the knife bearing. The pipe shall be placed upon the fillet while the plaster of Paris is still somewhat plastic. The load shall be applied

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[1] See p. 546.

through an upper knife bearing of the same size and length as the lower bearing. A plaster-of-Paris fillet 1 in. wide shall be cast along the length of the crown of the pipe to equalize the lower bearing before the upper one is brought into contact.

Both of the bearings shall be sufficiently rigid to transmit and receive uniform loads throughout their lengths without deflection, and shall be so attached to the machine as to transmit and receive the maximum stresses produced by the tests without lost motion, vibration or sudden shock.

At the option of the consumer or purchaser the crushing test may be applied with sand bearings or with two or three-edge bearings.

The crushing strength shall be calculated by dividing the total load required to break each pipe by the net inside length of the barrel of the pipe, measuring from the bottom of the socket to the end of the spigot; and by then multiplying the quotient by the following factors:

For knife or two-edge bearings........................	$\frac{10}{7}$
" three-edge bearings............................	$\frac{10}{7}$
" sand bearings..................................	1.00

Three-Edge Bearings.

12. (See Fig 2, Plate VI.)—When three-edge bearings are used, the ends of each specimen of pipe shall be accurately marked in halves of the circumference prior to the test.

The two lower bearings shall consist of two wooden strips with vertical sides, each strip having its interior top corner rounded to a radius of approximately ½ in. They shall be straight, and shall be securely fastened to a rigid block with their interior vertical sides 1 in. apart.

The upper bearing shall be a wooden block, straight and true from end to end.

The test load shall be applied through the upper bearing block in such a way as to leave the bearing free to move in a vertical plane passing midway between the lower bearings.

In testing a pipe which is "out of sight," the lines of the bearings chosen shall be from those which appear to give most favorable conditions for fair bearings.

Sand Bearings

13. (See Fig. 3, Plate VI.)—When sand bearings are used, the ends of each specimen of pipe shall be accurately marked

prior to the test in quarters of the circumference. Specimens shall be carefully bedded, above and below, in sand, for one-fourth the circumference of the pipe measured on the middle line of the barrel. The depth of bedding above and below the pipe at the thinnest points shall be one-half the radius of the middle line of the barrel.

The sand used shall be clean, and shall be such as will pass a No. 4 screen.

The top bearing frame shall not be allowed to come in contact with the pipe nor with the top bearing plate. The upper surface of the sand in the top bearing shall be struck level with a straight edge, and shall be covered with a rigid top bearing plate, with lower surface a true plane, made of heavy timbers or other rigid material, capable of distributing the test load uniformly without appreciable bending. The test load shall be applied at the exact center of this top bearing plate, in such a manner as to permit free motion of the plate in all directions. For this purpose a spherical bearing is preferred, but two rollers at right angles may be used. The test may be made without the use of a testing machine, by piling weights directly on a platform resting on the top bearing plate, provided, however, that the weights shall be piled symmetrically about a vertical line through the center of the pipe, and that the platform shall not be allowed to touch the top bearing frame.

The frames of the top and bottom bearings shall be made of timbers so heavy as to avoid appreciable bending by the side pressure of sand. The interior surfaces of the frames shall be dressed. No frame shall come in contact with the pipe during the test. A strip of cloth may, if desired, be attached to the inside of the upper frame on each side, along the lower edge, to prevent the escape of sand between the frame and the pipe.

Number of Specimens.

14. The crushing test shall ordinarily be applied to not less than 75 per cent of the specimens received for testing purposes.

Specimens for Absorption Test.

15. Pieces of the crushed pipe may be used as specimens in making the absorption test.

(*B*) *Hydrostatic Test.*

Hydrostatic Test.

16. Sound full-size pipe not exceeding about 25 per cent of the specimens received for test in each size of pipe, shall be tested for leakage under internal hydrostatic pressure.

The ends of the pipe shall be tightly closed by wooden or metallic bulkheads or covers faced with rubber or leather so that no leakage shall occur through the covers at the test pressure. One cover shall be provided with a ¾-in. wrought-iron nipple passing through the cover, and held securely in place and made water-tight by means of locknuts and washers or gaskets. The outer end of the nipple shall be connected with a pump discharge or water service line.

Water pressures, as measured by a standardized gage attached to the delivery pipe close to the specimen, shall be internally applied to the specimen as follows:

5 lb. per sq. in. for 5 minutes
10 " " for 10 "
15 " " for 15 "

The specimens shall show no leakage under these pressures. Moisture appearing on the surface of the pipe in the form of patches or beads, adhering to the surface, shall not be considered leakage.

(*C*) *Absorption Test.*

Test Specimens. 17. The specimens shall be sound pieces with all edges broken, and may be from pipes broken in the crushing or other tests. They shall be from 12 to 20 sq. in. in area, and shall be as nearly square as they can be readily prepared. They shall be free from observable cracks, fissures, laminations or shattered edges.

Drying. 18. Preparatory to the absorption test, the specimen shall be first weighed and then dried in a drier or oven at a temperature of not less than 110° C. (230° F.) for not less than three hours. After removal from the drier, the specimen shall be allowed to cool in dry air to a temperature of 20 to 25° C. (68 to 77° F.), and then reweighed.

If the specimen is comparatively dry when taken, and the second weight closely agrees with the first, it shall be considered dry. If the specimen is wet when taken it shall be placed in the drier for a drying treatment of two hours and reweighed. If the third weight checks the second the specimen shall be considered dry. In case of any doubt, the specimen shall be redried for two-hour periods, until check weights are obtained.

Weighing. 19. The balance used shall be sensitive to 0.5 g. when loaded with 1 kg., and weighings shall be read to the nearest gram. When other than metric weights are used, the same degree of accuracy shall be obtained.

Immersion. 20. The specimen, after final drying, cooling and weighing shall be placed with other similar specimens in a suitable wire receptacle, packed tightly enough to prevent jostling, covered with distilled water or rainwater, raised to the boiling point and boiled for five hours, and then cooled in water to a final temperature of 10 to 15° C. (50 to 59° F.).

Reweighing. 21. The specimen shall be allowed to drain for one minute, and, the superficial moisture having been removed by towel or blotting paper, placed upon the balance.

Calculation of Absorption. 22. The test result shall be calculated as percentage of the initial dry weight.

Number of Specimens. 23. One specimen shall be tested of each pipe broken in the crushing test.

Reporting Results. 24. The results shall be reported separately for each individual specimen together with the mean for all the specimens from the same shipment of pipe.

Identification. 25. Each specimen shall be marked so that it may be identified with the pipe used in the crushing test from which the specimen was taken. The marking shall be applied so that the pigment used shall not cover more than 1 per cent of the total superficial area of the specimen.

IV. PHYSICAL TEST REQUIREMENTS.

Physical Test Requirements. 26. The test requirements of cement-concrete pipe shall be as given in Table II. The individual results of the various tests for each size of pipe and for each shipment class and mill shall be tabulated separately so as to show the percentage which fails to comply with the requirements of each test.

V. A.S.T.M. SIZES AND DIMENSIONS.

Sizes and Dimensions. 27. Pipes shall be furnished of the sizes, internal diameter, and with the dimensions given in Tables III and IV. Where several lengths are mentioned in the table the consumer or purchaser shall indicate, at the time of purchase, which lengths shall be furnished; and unless so indicated, the manufacturer shall furnish such lengths as he may elect.

Permissible Variations. 28. The permissible variation from the dimensions given in Table III shall not exceed those stated in Table IV. Where the thickness of barrel is increased beyond that given in Table III in order to meet the specified requirements of strength, the diameter at inside of socket shall be increased by double the increase in thickness of barrel. Pipes intended to be straight shall not have variation in alignment of more than $\frac{1}{8}$ in. per foot of length.

TABLE II.—PHYSICAL TEST REQUIREMENTS OF CEMENT-CONCRETE SEWER PIPE.

Internal Diamter, in.	Minimum Crushing Strength, lb. per lin. ft.	Maximum Percolation, gal. per mile in 24 hr.	Maximum Absorption, per cent.
6	1430	These requirements will be furnished later.	8
8	1430		8
10	1570		8
12	1710		8
15	1960		8
18	2200		8
21	2590		8
24	3070		8
27	3370		8
30	3690		8
33	3930		8
36	4400		8
39	4710		8
42	5030		8

VI. WORKMANSHIP AND FINISH.

Absence of Defects. 29. Pipes shall be substantially free from fractures, large or deep cracks and blisters, laminations and surface roughness.

Finish of Ends. 30. The ends of the pipes shall be square with their longitudinal axis.

Specials. 31. (*a*) Special shapes shall have a plain spigot end and a socket end corresponding in all respects with the dimensions specified for pipes of the corresponding internal diameter. Branches shall be furnished to lay the same lengths as straigh pipe. All specials shall conform in finish to the specifications for pipes given in Sections 29 and 30.

(*b*) Slants shall have their spigot ends cut at an angle of approximately 45 deg. with the longitudinal axis.

(*c*) Curves shall be at angles of 90, 45, $22\frac{1}{2}$ deg., as required. They shall conform substantially to the curvature specified.

(*d*) Branches shall be furnished with the connection or connections of the size or sizes specified, securely and completely fastened in the process of manufacture to the barrel of the pipe. T-branches and double T-branches shall have the axis perpendicular to the longitudinal axis of the pipe. Y-branches, double Y-branches, and V-branches shall have their axes approximately 45 deg. from the longitudinal axis of the pipe measured from the socket end. All branches shall terminate in sockets and the barrel of the branch shall be of sufficient length to permit making a proper joint when the connecting pipe is inserted in the branch socket.

TABLE III.—DIMENSIONS OF CEMENT-CONCRETE SEWER PIPE.

Internal Diameter (D), in.	Laying Length (L), ft.	Normal Diameter at End of Socket (D_S), in.[1]	Depth of Socket (L_S), in.	Taper of Socket (H).	Thickness of Barrel (T), in.	Thickness of Socket (T_S).
6	2	$8\frac{1}{4}$	2	1 : 20	$\frac{5}{8}$	The thickness of the socket $\frac{1}{4}$ in. from its outer end shall be not less than three-quarters of the thickness of the barrel of the pipe.
8	2, $2\frac{1}{2}$, 3	$10\frac{3}{4}$	$2\frac{1}{4}$	1 : 20	$\frac{3}{4}$	
10	2, $2\frac{1}{2}$, 3	13	$2\frac{1}{2}$	1 : 20	$\frac{7}{8}$	
12	2, $2\frac{1}{2}$, 3	$15\frac{1}{4}$	$2\frac{1}{2}$	1 : 20	1	
15	2, $2\frac{1}{2}$, 3	$18\frac{3}{4}$	$2\frac{1}{2}$	1 : 20	$1\frac{1}{4}$	
18	2, $2\frac{1}{2}$, 3	$22\frac{1}{4}$	$2\frac{3}{4}$	1 : 20	$1\frac{1}{2}$	
21	2, $2\frac{1}{2}$, 3	26	$2\frac{3}{4}$	1 : 20	$1\frac{3}{4}$	
24	2, $2\frac{1}{2}$, 3	$29\frac{1}{2}$	3	1 : 20	$2\frac{1}{8}$	
27	3	$33\frac{1}{4}$	$3\frac{1}{4}$	1 : 20	$2\frac{1}{4}$	
30	3	37	$3\frac{1}{2}$	1 : 20	$2\frac{1}{2}$	
33	3	$40\frac{1}{4}$	4	1 : 20	$2\frac{3}{4}$	
36	3	44	4	1 : 20	3	
39	3	$47\frac{1}{4}$	4	1 : 20	$3\frac{1}{4}$	
42	3	51	4	1 : 20	$3\frac{1}{2}$	

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[1] When pipes are furnished having an increase in thickness over that given in last column, then the diameter of socket shall be increased by an amount equal to twice the increase of thickness of barrel.

(*e*) Channel or split pipe, curves and branches shall be accurate half sections of the corresponding size of pipe or other specials.

VII. MARKINGS.

Markings. 32. Pipes shall bear the initials or name of the person, company or corporation by whom they are manufactured, and the location of the mill. The markings shall be indented or stenciled on the exterior or interior of the barrel near the socket and shall be plainly legible for purpose of identification.

TABLE IV.—PERMISSIBLE VARIATIONS IN DIMENSIONS OF CEMENT-CONCRETE SEWER PIPE.

Normal Size, in.	Limits of Permissible Variation in:				
	Length, in. per ft. (−)	Internal Diameter, in.		Depth of Socket, in. (−)	Thickness of Barrel, in. (−)
		Spigot (±)	Socket (±)		
6	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{1}{16}$
8	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{16}$
10	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{16}$
12	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{16}$
15	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{3}{32}$
18	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{3}{32}$
21	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{1}{8}$
24	$\frac{3}{8}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{1}{8}$
27	$\frac{3}{8}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{1}{8}$
30	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{1}{8}$
33	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{3}{16}$
36	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{3}{16}$
39	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{3}{16}$
42	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{3}{16}$

NOTE.—The minus sign (−) alone indicates that the plus variation is not limited; the plus and minus sign (±) indicates variation in both excess and deficiency in dimension.

VIII. INSPECTION.

Inspection. 33. All pipes shall be subject to inspection at the factory, trench or other point of delivery by a competent inspector employed by the consumer or purchaser. The purposes of the inspection shall be to cull and reject pipes which, independent of the physical tests herein specified, fail to meet the requirements of these specifications.

Rejection.

34. Pipes shall be subject to rejection on account of the following:

(*a*) Variations in any dimension exceeding the permissible variations given in Table IV.

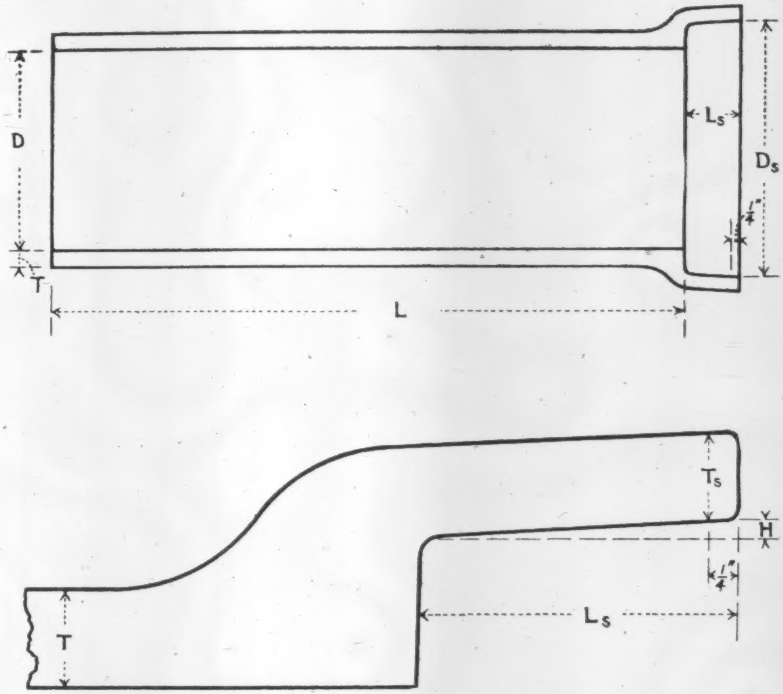

FIG. 4. Application of Dimensions given in Table III.

(*b*) Fracture or cracks passing through the shell or socket, except that a single crack at either end of a pipe not exceeding 2 in. in length or a single fracture in the socket not exceeding 3 in. in width nor 2 in. in length will not be deemed cause for rejection unless these defects exist in more than 5 per cent of the entire shipment or delivery.

(*c*) Blisters where the surface is broken or which project more than $\frac{1}{8}$ in. above the surface.

(*d*) Defects which indicate imperfect mixing and molding.

(*e*) Cracks sufficient to impair the strength, durability or serviceability of the pipe.

(*f*) Variation of more than ⅛ in. per linear foot in alignment of a pipe intended to be straight.

(*g*) Failure to give a clear ringing sound when placed on end and dry-tapped with a light hammer.

(*h*) Insecure attachment of branches on spurs.

Marking of Rejected Specimens.

35. All rejected pipes shall be plainly marked by the inspector and shall be replaced by the manufacturer or seller with pipes which meet the requirements of these specifications, without additional cost to the consumer or purchaser.

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TENTATIVE SPECIFICATIONS
FOR
REQUIRED SAFE CRUSHING STRENGTHS OF SEWER PIPE TO CARRY LOADS FROM DITCH FILLING.[1]

Serial Designation: C 15 – 17 T.

These specifications are issued under the fixed designation C 15; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

The following table gives required safe crushing strengths per linear foot of pipe, to carry loads from ditch filling materials only when pipe is laid in accordance with the Recommended Practice for Laying Sewer Pipe (Serial Designation: C 12) of the American Society for Testing Materials,[2] for sand and for thoroughly wet clay ditch filling materials. In the preparation of this table a safety factor of 1½ has been used, which has been found necessary to prevent cracking from the loads of ditch filling.[3]

Ordinary Pipe Laying is pipe laying in accordance with customary good practice in pipe sewer construction, whereby the under side of the pipe is well bedded on soil for 60 to 90 deg. of the circumference.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. Rudolph Hering, Chairman of Committee C-4 on Clay and Cement Sewer Pipe, 170 Broadway, New York City.

[2] Supplementary Pamphlet of A.S.T.M. Standards Adopted in 1919.

[3] Prepared from the Standard Specificationsfor Drain Tile (C 4), 1918 Book of A.S.T.M. Standards.

First Class Pipe Laying is pipe laying in accordance with the best customary practice in pipe-sewer construction, whereby the entire under side of the pipe is very thoroughly bedded on soil and the entire pipe is surrounded by well-compacted soil, under the direction of an inspector constantly present on the work.

SAFE CRUSHING STRENGTHS OF SEWER PIPE TO CARRY LOADS FROM DITCH FILLING FOR ORDINARY SAND AND FOR THOROUGHLY WET CLAY DITCH FILLING MATERIALS.
(FOR ORDINARY PIPE-LAYING METHODS.)
STRENGTHS IN POUNDS PER LINEAR FOOT.

Height of Fill above Top of Pipe, ft.	Breadth of Ditch a Little Below Top of Pipe.									
	1 ft.		2 ft.		3 ft.		4 ft.		5 ft.	
	Ditch Filling Material.		Ditch Filling Material.		Ditch Filling Material.		Ditch Filling Material.		Ditch Filling Material.	
	Sand.	Clay.	Sand.	Clay	Sand.	Clay.	Sand.	Clay.	Sand.	Clay.
2	265	280	615	635	970	990	1 330	1 350	1 690	1 710
4	400	450	1 055	1 125	1 745	1 825	2 455	2 535	3 165	3 250
6	470	545	1 370	1 500	2 370	2 525	3 405	3 575	4 460	4 640
8	505	605	1 600	1 790	2 875	3 115	4 215	4 495	5 595	5 890
10	525	640	1 765	2 015	3 275	3 610	4 900	5 295	6 590	7 090
12	535	660	1 880	2 185	3 600	4 030	5 485	6 000	7 460	8 035
14	540	675	1 965	2 320	3 855	4 380	5 975	6 620	8 225	8 950
16	545	680	2 025	2 425	4 065	4 675	6 395	7 165	8 890	9 775
18	545	685	2 070	2 505	4 230	4 920	6 750	7 630	9 480	10 520
20	545	690	2 100	2 565	4 365	5 130	7 050	8 060	9 995	11 190
22	545	690	2 125	2 610	4 470	5 305	7 305	8 425	10 445	11 795
24	545	690	2 140	2 645	4 560	5 455	7 525	8 750	10 840	12 840
26	545	690	2 150	2 675	4 630	5 575	7 705	9 035	11 185	12 830
28	545	690	2 160	2 695	4 685	5 680	7 860	9 280	11 490	13 270
30	545	690	2 165	2 715	4 725	5 765	7 990	9 500	11 755	13 670
Very great	545	690	2 180	2 770	4 910	6 230	8 725	11 075	13 635	17 305

When pipe are laid in a *Concrete or other Permanent Masonry Cradle*, strong enough to carry the entire load to the sub-base without breaking and large enough to prevent material settlement, the standard strengths for all dimensions of ditches and all filling materials shall be those specified for standard sewer pipe.

AMERICAN SOCIETY FOR TESTING MATERIALS
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TENTATIVE SPECIFICATIONS
FOR
MASONS' HYDRATED LIME.[1]

Serial Designation: C 6 – 19 T.

These specifications are issued under the fixed designation C 6; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917: REVISED 1919.

Definition. 1. Masons' hydrated lime is a dry flocculent powder, resulting from the hydration of quicklime.

Uses. 2. Masons' hydrated lime may be used for making lime mortar, for scratch or brown coat of plaster, or for addition to Portland-cement mortar or concrete.

I. CHEMICAL PROPERTIES AND TESTS.

Sampling. 3. The sample shall be a fair average of the shipment. Three per cent of the packages shall be sampled. The sample shall be taken from the surface to the center of the package. A 2-lb. sample to be sent to the laboratory shall immediately be transferred to an air-tight container, in which the unused portion shall be stored until the shipment has been finally accepted or rejected by the purchaser.

Chemical Properties. 4. (*a*) The chemical composition of the hydrated lime shall be determined by standard methods of chemical analysis.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1. 1920, to Mr. N. G. Hough, Secretary of Committee C-7 on Lime, 918 G St., N. W., Washington, D. C.

These specifications, when adopted as standard, will supercede the present Standard Specifications for Hydrated Lime (Serial Designation: C 6-15), 1918 Book of A.S.T.M. Standards.

(*b*) *Impurities.*—The sum of the silica (SiO_2), ferric oxide (Fe_2O_3) and alumina (Al_2O_3) expressed on the sample as received shall not exceed 5 per cent.

(*c*) *Carbon Dioxide.*—Carbon dioxide in the sample as received shall not exceed 3 per cent.

(*d*) *Calcium and Magnesium Oxides.*—Calcium and magnesium oxides shall constitute not less than 90 per cent of the non-volatile portion.

II. PHYSICAL PROPERTIES AND TESTS.

Fineness.

5. (*a*) A 100-g. sample shall leave not more than 0.5 per cent of its weight on a standard 30-mesh sieve, and not more than 15 per cent of its weight on a standard 200-mesh sieve.

(*b*) The fineness test shall be made as specified in Section 12.

Constancy of Volume.

6. (*a*) A pat of mortar, covered with a skim coat of neat paste, shall be subjected to the action of steam. If the steam has no visible effect on the pat, the sample shall be reported as being "sound." If the pat disintegrates, the sample shall be reported "unsound" and the shipment rejected. If the sample cracks, pops, or shows other minor defects, it shall not be reported as either sound or unsound, but its behavior shall be noted.

(*b*) The constancy of volume test shall be made as specified in Section 13.

III. PACKING AND MARKING.

Packing.

7. (*a*) *Kind of Package.*—The hydrated lime shall be packed in either cloth or paper bags.

(*b*) *Size of Package.*—The cloth package shall contain 100 lb. net weight of hydrated lime. The paper package shall contain 50 lb. net weight of hydrated lime.

Marking.

8. Each package shall be clearly marked to show the net weight of hydrated lime contained in the package, the name of the manufacturer, and the name of the brand, if any.

IV. INSPECTION AND REJECTION.

Inspection.

9. (*a*) All hydrated lime shall be subject to inspection.

(*b*) Hydrated lime may be inspected either at the place of manufacture or the point of delivery, as arranged at the time of purchase.

(*c*) The manufacturer shall furnish the inspector all reasonable facilities for inspection and sampling, which shall be so conducted as not to interfere with the operation of the works.

(*d*) The purchaser may make the tests to govern the acceptance or rejection of the hydrated lime in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

Rejection.

10. Unless otherwise specified, any rejection based on failure to pass tests prescribed in these specifications shall be reported within five working days from the taking of samples.

Rehearing.

11. Samples which represent rejected hydrated lime shall be preserved in air-tight containers for five days from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

V. METHODS OF TEST.

Method for Determining Fineness.

12. Fineness of hydrated lime shall be determined as follows:

Place 100 g. of the sample as received on a standard 30-mesh sieve having openings averaging 0.0198 in. This sieve shall be nested above a standard 200-mesh sieve having openings averaging 0.0029 in. Wash the material by means of a stream of water from a faucet. A small piece of rubber tubing attached to a water faucet will be found convenient. The velocity of the stream of water can be increased by pinching the tubing, but it should not be sufficient to cause any danger of splashing the sample over the sides of the sieve. Continue the washing until the water coming through the sieve is clear. Then dry the residue upon the 30-mesh sieve to constant weight in a drying oven whose temperature is maintained between 100 and 120° C. in an atmosphere free from carbon dioxide. Calculate the weight of this residue as percentage of the original sample. Then wash the material which has passed the 30-mesh sieve and remained on the 200-mesh sieve through the latter as described above. Treat the residue on this sieve in the same manner as described above for the 30-mesh sieve and add the percentage retained to the percentage residue on the 30-mesh sieve. The sum of these two shall be reported as the residue on the 200-mesh sieve.

Method for Determining Constancy of Volume.

13. Constancy of volume shall be determined as follows:

To 20 g. of the sample, add 100 g. of clean, washed, graded sand which shall all pass the No. 20 sieve and which shall all be retained on the No. 100 sieve. Mix thoroughly and add enough water to make a good plastic mortar of a rather dry consistency. Spread out on a clean glass plate, to form a layer about $\frac{1}{8}$ in. thick by about 4 in. square. The pat shall be of even thickness throughout, and not tapering at the edges. If the mortar is too dry to work well, add more water. Place this pat in a closet to set for 24 hours. The temperature in the closet should be between 65 and 75° F., and there should be free circulation of air in the closet, without allowing any direct draft to hit the pat. At the end of 24 hours remove the pat from the closet and soak it in water, until a film of water stands unabsorbed on the surface of the pat. Examine the pat carefully for cracks. If any are found, too much water was used in making the pat, and it should be discarded and a new one made.

Mix 20 g. of the sample with enough water to form a thick cream. Spread this out in a thin layer on the surface of the pat. Let it stand for 15 minutes to permit possible air bubbles to form. Trowel to a smooth even surface, making this skim coat as thin as possible without allowing the sand to show through. Put the pat back in the closet for another 24 hours, so that the skim coat can set. Examine carefully, to insure the absence of any cracks or pops. Provide a vessel partially filled with cold water, and having a perforated cover. Suspend the pat in this vessel in such a way that the water can boil without touching it. Gradually bring the water to a boil, and keep it boiling gently for 5 hours, the pat being surrounded by steam during this time. Turn out the fire, and permit the water to cool for at least 12 hours before the cover is removed from the vessel. The pat is then removed and examined for cracking, popping or disintegration.

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TENTATIVE SPECIFICATIONS
FOR
GYPSUM.[1]

Serial Designation: C 22 – 19 T.

These specifications are issued under the fixed designation C 22; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

Definition.

1. (*a*) Pure gypsum is calcium sulfate combined in crystallin form with two molecules of water. Its chemical formula is $CaSO_4 \cdot 2H_2O$.

(*b*) No material may be considered gypsum within the meaning of these specifications which contains more than 35.5 per cent by weight of impurities.

Forms and Sizes.

2. Gypsum may be sold in any of the following forms and sizes:

(*a*) *Run-of-Mine.*—The form in which it comes from the mine or quarry.

(*b*) *Broken.*—Run-of-mine gypsum further reduced to sizes suitable for specific uses. Broken gypsum may be sold in any of the following sizes:[2]

No. 1.—Screen-run gypsum, all of which passes a 3-in. ring.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. V. G. Marani, Secretary of Committee C-11 on Gypsum, 111 W. Monroe St., Chicago, Ill.

[2] The following definition was adopted by the Gypsum Industries Association on June 18, 1919:

> *Broken or Crushed.*—Run-of-mine gypsum further reduced to sizes suitable for specific uses. Broken or crushed gypsum may be sold as follows:
>
> Broken or crushed gypsum shall all pass through a 3-in. ring, not to exceed 25 per cent shall pass through a 100-mesh screen, and not less than 10 per cent shall be retained on a $\frac{3}{16}$ in. or equal mesh screen.

No. 2.—Screen-run gypsum, all of which passes a 1½-in. ring.

No. 3.—Screen-run gypsum, all of which passes a ¾-in. ring.

(*c*) *Ground.*—Broken gypsum further reduced to sizes suitable for specific uses. Ground gypsum may be sold in any of the following sizes:

No. 4.—Material of this size shall all pass an 8-mesh sieve, and not less than 40 nor more than 60 per cent of it shall pass a 100-mesh sieve.

No. 5.—Material of this size shall all pass an 8-mesh sieve, and not less than 60 nor more than 80 per cent of it shall pass a 100-mesh sieve.

No. 6.—Material of this size shall all pass an 8-mesh sieve, and not less than 80 per cent of it shall pass a 100-mesh sieve.

I. SAMPLING.

Sampling from Bulk.

3. When gypsum is shipped in bulk, samples of about 5 lb. each shall be taken at regular intervals during the complete loading or unloading of the car, in such a way as to accumulate at least 200 lb. of material. This shall be broken so that it will all pass a 1-in. ring, thoroughly mixed, and reduced by quartering to provide not less than a 1-lb. sample for the laboratory.

Sampling from Packages.

4. When gypsum is shipped in packages, at least 3 per cent of the packages shall be sampled. Samples shall be taken from both the surface and the center of the packages. These samples shall then be broken, mixed, and quartered as directed above.

Laboratory Samples.

5. All laboratory samples shall be placed immediately in an air-tight container and shipped to the laboratory for test.

II. CHEMICAL PROPERTIES.

Chemical Properties.

6. (*a*) Since it is customary to buy gypsum on the basis of its SO_3 content, its chemical properties are a matter of contract rather than specification.

(*b*) Each package or each shipment of gypsum shall be accompanied by a card stating its minimum content of CaO and SO_3. (See Section 10.) Failure to meet this guarantee will constitute a basis for rejection under these specifications.

III. PHYSICAL PROPERTIES.

Fineness. 7. Gypsum may be purchased either as run-of-mine, or in one of the six sizes enumerated in Section 2. Each package or each shipment of gypsum shall be accompanied by a card stating the size of the material. (See Section 10.) Failure to meet this guarantee will constitute a basis for rejection under these specifications.

Color. 8. Specification to be supplied by the Committee when the information is available.

IV. TESTING.

Tests. 9. The chemical and physical properties of gypsum shall be determined in accordance with the Tentative Methods for Tests of Gypsum and Gypsum Products (Serial Designation: C 26–19 T) of the American Society for Testing Materials.[1]

V. PACKING AND MARKING.

Packing and Marking. 10. Gypsum may be shipped either in packages or in bulk.

(*a*) When shipped in packages for resale, the following information shall be legibly marked on each package or on a tag of suitable size attached thereto:

Name of manufacturer;
Form and size of material;
Chemical analysis of the material, giving the minimum percentages of CaO and SO_3;
Net weight of package.

(*b*) When shipped in bulk, a card containing the above information shall be securely fastened to the car.

VI. INSPECTION AND REJECTION.

Inspection. 11. Inspection may be made either at the point of shipment or at the point of delivery. The inspector representing the purchaser shall have free access to the cars being loaded for shipment to the purchaser. He shall be afforded all reasonable facilities for inspection and sampling, which shall be so conducted as not to interfere unnecessarily with the loading of the cars.

Rejection. 12. Any rejection based upon failure to conform to the requirements of these specifications shall be reported within five working days from the receipt of the shipment by the consignee.

Rehearing. 13. Claim for rehearing shall be valid only if filed within five working days from receipt of notice of rejection.

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[1] See p. 613.

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TENTATIVE SPECIFICATIONS
FOR
CALCINED GYPSUM.[1]

Serial Designation: C 23 - 19 T.

These specifications are issued under the fixed designation C 23; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

Definition. 1. Calcined gypsum is the product resulting from the partial (incomplete), or complete dehydration of gypsum by means of heat.

Classes. 2. Calcined gypsum is divided into three classes on the basis of its purity, as follows:

Class A.—Containing not less than 88.4 per cent of $CaSO_4 \cdot \frac{1}{2}H_2O$ if partially dehydrated, or not less than 87.6 per cent of $CaSO_4$ if totally dehydrated. (These figures correspond to 90-per-cent purity in the raw gypsum rock.)

Class AA.—Containing not less than 71.7 per cent of $CaSO_4 \cdot \frac{1}{2}H_2O$ if partially dehydrated, or not less than 70.4 per cent of $CaSO_4$ if totally dehydrated, nor more than the similar quantities specified for Class A. (These figures correspond to 75-per-cent purity in the raw gypsum rock.)

Class AAA.—Containing not less than 60.5 per cent of $CaSO_4 \cdot \frac{1}{2}H_2O$ if partially dehydrated, or not less than 59 per cent of $CaSO_4$ if totally dehydrated, nor more than the similar quantities specified for Class AA. (These figures correspond to 64.5-per-cent purity in the raw gypsum rock.)

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. V. G. Marani, Secretary of Committee C-11 on Gypsum, 111 W. Monroe St., Chicago, Ill.

I. SAMPLING.

3. At least 3 per cent of the packages shall be sampled. Samples shall be taken from both the surface and the center of the packages. The material so obtained shall be thoroughly mixed and reduced by quartering to provide not less than a 15-lb. sample for the laboratory. This sample shall be placed immediately in an air-tight container and shipped to the laboratory for test. **Sampling.**

II. CHEMICAL PROPERTIES.

4. The chemical composition of the sample shall conform to the limits prescribed for its class. (See Section 2.) Failure to conform to these requirements will constitute a basis for rejection under these specifications. **Chemical Properties.**

III. PHYSICAL PROPERTIES.

5. Partially calcined gypsum (all classes) shall set in not less than 10 nor more than 50 minutes. **Time of Set.**

6. Calcined gypsum (all classes) may be sold in one of the following sizes: **Fineness.**

No. 4.—Material of this size shall all pass an 8-mesh sieve, and not less than 40 nor more than 60 per cent of it shall pass a 100-mesh sieve.

No. 5.—Material of this size shall all pass a 14-mesh sieve, and not less than 60 nor more than 80 per cent of it shall pass a 100-mesh sieve.

No. 6.—Material of this size shall all pass a 28-mesh sieve, and not less than 80 per cent of it shall pass a 100-mesh sieve.

7. When 100 lb. of partially calcined gypsum are mixed with water to form a paste of normal consistency, the volume of the paste produced shall be not less than . . . (To be supplied.) **Yield.**

8. Partially calcined gypsum (all classes) when mixed with water to form a paste of normal consistency, which is then molded into briquettes and allowed to set until dry, shall have a tensile strength of not less than 100 lb. per sq. in. **Tensile Strength.**

Compressive Strength. 9. Partially calcined gypsum (all classes) when mixed with water to form a paste of normal consistency, which is then molded into cylinders 4 in. high by 2 in. in diameter and allowed to set until dry, shall have a compressive strength of not less than 1000 lb. per sq. in.

Plasticity. 10. Specification to be supplied by the Committee when the information is available.

Color. 11. Specification to be supplied by the Committee when the information is available.

IV. TESTING.

Tests. 12. The chemical and physical properties of calcined gypsum shall be determined in accordance with the Tentative Methods for Tests of Gypsum and Gypsum Products (Serial Designation: C 26–19 T) of the American Society for Testing Materials.[1]

V. PACKING AND MARKING.

Packing and Marking. 13. Calcined gypsum shall be shipped in packages. When shipped for resale, the following information shall be legibly marked on each package or on a tag of suitable size attached thereto:

Name of manufacturer;
Brand;
Class of material;
Net weight of package.

VI. INSPECTION AND REJECTION.

Inspection. 14. Inspection may be made either at the point of shipment or at the point of delivery. The inspector representing the purchaser shall have free access to the cars being loaded for shipment to the purchaser. He shall be afforded all reasonable facilities for inspection and sampling, which shall be so conducted as not to interfere unnecessarily with the loading of the cars.

Rejection. 15. Any rejection based upon failure to conform to the requirements of these specifications shall be reported within ten working days from the receipt of the shipment by the consignee.

Rehearing. 16. Claim for rehearing shall be valid only if filed within five working days from receipt of notice of rejection.

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[1] See p. 613.

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TENTATIVE TEST
FOR
REFRACTORY MATERIALS UNDER LOAD AT HIGH TEMPERATURES.[1]

Serial Designation: C 16 – 18 T.

This test is issued under the fixed designation C 16; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917; REVISED, 1918.

1. The object of this test is to determine the resistance of the specimen to deformation at a specified temperature for a specified time, when subjected to a compressive load of 25 lb. per sq. in. (1.765 kg. per sq. cm.). **Object.**

2. The apparatus consists essentially of a furnace and loading device It shall be constructed in accordance with Figs. 1 and 2. **Apparatus.**

(*a*) The furnace shall be cylindrical in form, 18 in. (457 mm.) in internal diameter, as shown in Fig. 1 (Plate VII).

(*b*) The heating shall be done with gaseous or oil fuel and compressed air, using not less than two burners located tangentially and so arranged that no flame can impinge upon the test specimen. The burners shall be such as will insure a uniform temperature in all parts of the furnace and be under complete control.

(*c*) The method of loading shown in Fig. 1 shall be used, and the details shall be such as will insure accuracy in the applied load and freedom from eccentric loading, both in the original application and during the testing. It is advantageous to make the cross-beams as light as possible, so that the greater portion of the load may be concentrated in the weights.

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[1] Criticisms of this Tentative Test are solicited and should be directed, preferably before January 1, 1920, to Mr. A. V. Bleininger, Chairman of Committee C-8 on Refractories, Bureau of Standards, Pittsburgh, Pa.

TABLE I.—TEMPERATURE TO BE ATTAINED AT TIME SPECIFIED.

ALL TEMPERATURES IN DEGRESS CENTIGRADE.

Time.	Silica.	Fire Clay.		
		Heavy Duty.	Moderate Duty.	Light Duty.
Hr. Min.				
15	40	160	160	160
30	80	280	280	280
45	140	400	400	400
1 0	200	500	500	500
15	260	620	595	570
30	290	720	685	640
45	300	815	770	700
2 0	310	900	850	755
15	320	980	920	810
30	385	1045	990	860
45	490	1100	1050	905
3 0	590	1150	1100	950
15	695	1195	1145	985
30	800	1235	1185	1020
45	900	1270	1220	1050
4 0	1000	1300	1250	1075
15	1100	1330	1275	1090
30	1200	1350	1300	1100
45	1250	1350	1300	1100
5 0	1300	1350	1300	1100
15	1350	1350	1300	1100
30	1380	1350	1300	1100
45	1410	1350	1300	1100
6 0	1440	1350	1300	1100
15	1470	End	End	End
30	1500			
45	1500			
7 0	1500			
15	1500			
30	1500			
45	1500			
8 0	1500			
	End			

(*d*) The temperature may be measured either with a calibrated platinum-rhodium thermo-couple, encased in a double protecting tube with the junction not more than 1 in. (25 mm.) from the side or edge of the specimen and approximately opposite

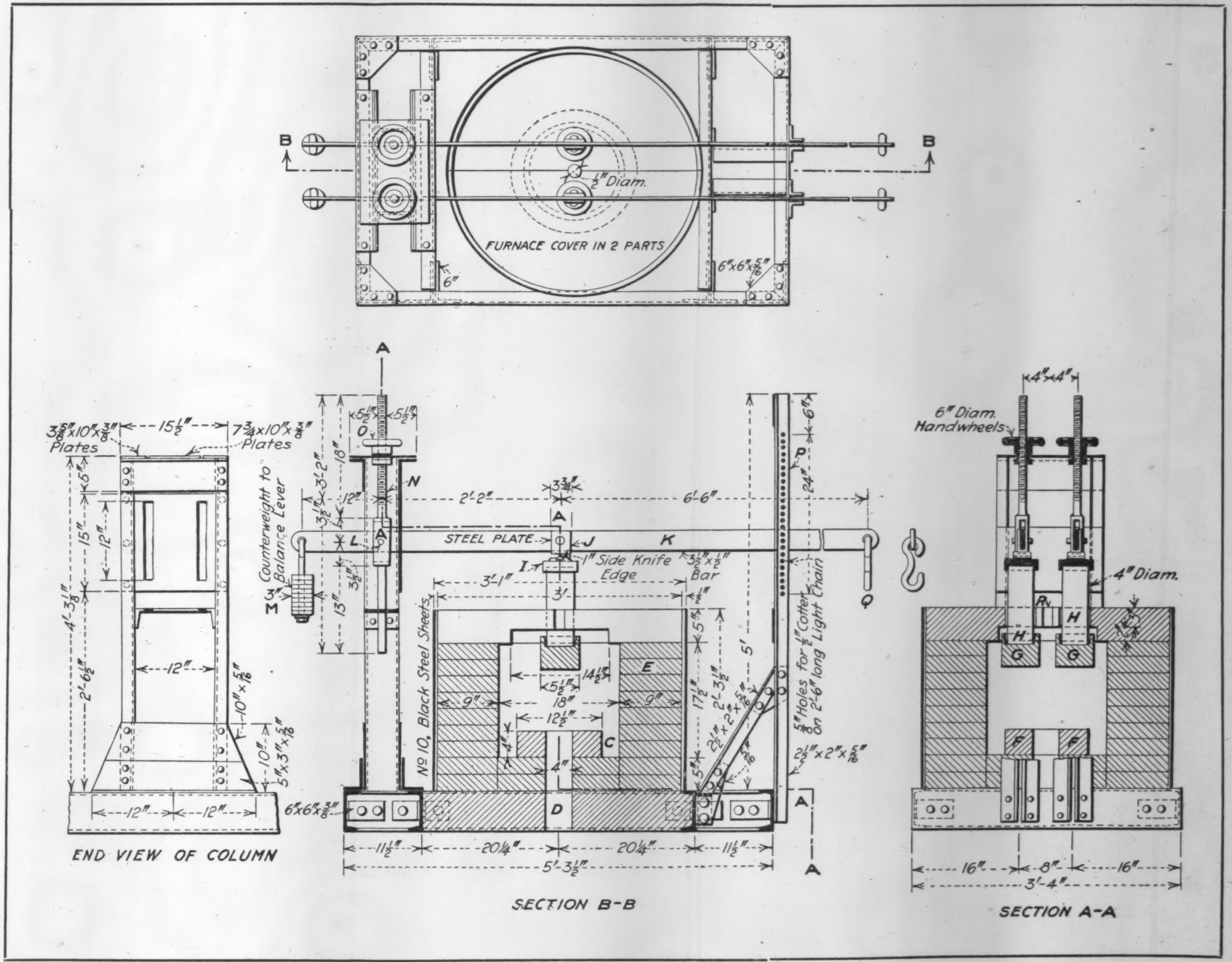
B
B
1/2" Diam.
FURNACE COVER IN 2 PARTS
6"
6"x6"x5/16"
3 5/8"x10"x3/8" Plates
15 1/2"
7 3/4x10"x3/8" Plates
5"
15"
12"
4'-3 1/8"
2'-6 1/2"
12"
10"x5/16"
10"
5"x3"x5/16"
12"
12"
END VIEW OF COLUMN
A
5 1/2"
5 1/2"
O
18"
3'-2"
N
12"
3 1/2"
Counterweight to Balance Lever
L
A
3"
M
3 1/2"
13"
2'-2"
3 3/4"
6'-6"
A
STEEL PLATE
J
K
I
1" Side Knife Edge
3 1/2"x1/2" Bar
3'-1"
3'
1/2"
No 10, Black Steel Sheets
5"
14 1/2"
5 1/2"
E
9"
18"
9"
12 1/2"
17 1/2"
2'-3 1/2"
4"
C
4"
5"
2 1/2"x2"x5/16"
5/16"
5'
6"
P
24"
5/8" Holes for 1/2" Cotter on 2'-6" long Light Chain
2 1/2"x2"x5/16"
Q
6"x6"x3/8"
D
A
11 1/2"
20 1/4"
20 1/4"
11 1/2"
5'-3 1/2"
A
SECTION B-B
4"
4"
6" Diam. Handwheels
4" Diam.
R
H
H
G
G
F
F
16"
8"
16"
3'-4"
SECTION A-A

FIG. 1.—Apparatus for Testing Refractory Materials under Load at High Temperatures.

(By courtesy of *Metallurgical and Chemical Engineering.*)

the center; or with some form of optical pyrometer that has been calibrated against a thermo-couple in the furnace. If the thermo-couple is used, the cold-end temperature should be kept constant in melted ice. A recording form of indicator is recommended where possible.

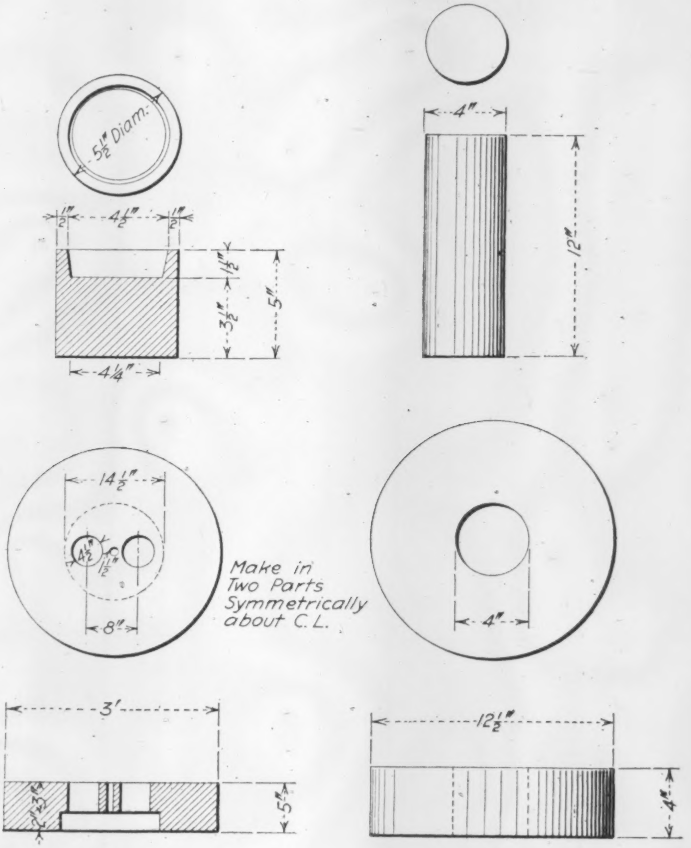
5½" Diam.
½"
4½"
½"
1½"
5"
3½"
4¼"
4"
12"
14½"
4½"
1½"
8"
Make in Two Parts Symmetrically about C.L.
4"
3'
5"
2"
3"
12½"
4"
A
B

FIG. 2.—Special Shapes Required for Furnace.
(By courtesy of *Metallurgical and Chemical Engineering*.)

Test Specimen. 3. The test specimen shall consist, whenever possible, of a standard 9-in. brick placed vertically on end. In the case of blocks or shapes, sections approximately 9 by $4\frac{1}{2}$ by $2\frac{1}{2}$ in. (228 by 114 by 64 mm.) shall be cut, utilizing as far as possible existing plane surfaces. The ends of the specimen shall be either ground so that they are parallel and perpendicular to the vertical axis, or if this is impossible, shall be bedded in a neutral cement, so that the specimen is perpendicular to the base of the furnace.

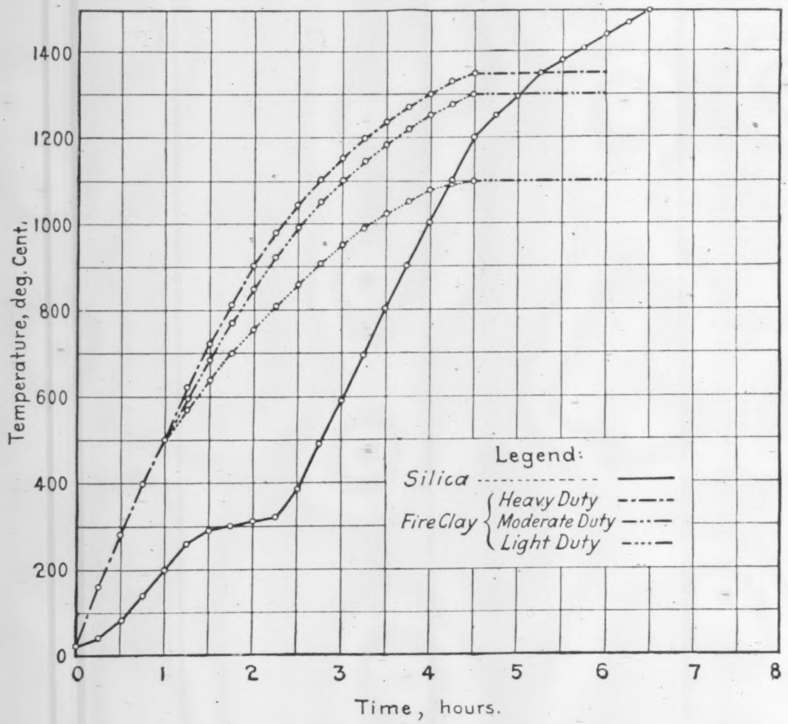

FIG. 3.—Time-Temperature Curve for Load Test.

The test specimen shall be measured before testing, making not less than five observations in each direction to within ±0.02 in. (0.5 mm.). The average dimensions shall be reported, and the cross-section calculated.

Starting the Test. 4. The test specimen shall occupy approximately the center of the furnace and should rest on a block of some highly refractory material, having a minimum expansion or contraction. A silicon-carbide brick has been found satisfactory. At the top of the test specimen a block of similar highly refractory material should be placed, extending through the furnace top to receive the load.

Heating.

5. The rate of heating shall be in accordance with the requirements of Table I and the time-temperature curves of Fig. 3, which give the rate and time of heating suggested for different grades of material.

Loading.

6. (*a*) The load is calculated from the average cross-section as determined on the untested specimen and the requirement of the test. It is recommended that for general purposes, 25 lb. per sq. in. (1.765 kg. per sq. cm.) be used.

(*b*) The additional masses required to give the desired loading should be equally distributed on each side of the beam.

Completing the Test.

7. (*a*) At the expiration of the time of heating, the supply of heat shall be stopped and the furnace allowed to cool, during not less than 5 hours before removing the load and examining the test specimen.

(*b*) After the test specimen has cooled to the room temperature, it shall be remeasured as before described, and the change in length recorded and reported as percentage of the original length.

(*c*) It is recommended that a photograph be made of the specimen before and after testing, as yielding valuable information at a minimum time and expense.

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TENTATIVE TEST
FOR
SLAGGING ACTION OF REFRACTORY MATERIALS.[1]

Serial Designation: C 17 – 19 T.

This test is issued under the fixed designation C 17; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917; REVISED, 1919.

Preparation of Samples.

1. Select three or more of the bricks to be tested. Draw upon the smooth or unbranded side a line bisecting each brick across the narrow dimension. Draw diagonals across each half. The points of intersection of the diagonals locate the centers of rings. Where samples do not conform to the standard 9-in. brick, one or more points may be located on any flat smooth surface, provided the centers of rings do not approach closer than 2 in. to any edge of that surface, and if more than one point is chosen, the centers lie not closer than 4½ in. from each other.

The rings shall be 2½ in. in inside diameter, and ½ in. deep, and with walls ½ in. thick. The rings shall be made of well-burned clay[2] and shall be cemented on the brick with a refractory

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[1] Criticisms of this Tentative Test are solicited and should be directed, preferably before January 1, 1920, to Mr. A. V. Bleininger, Chairman of Committee C-8 on Refractories, Bureau of Standards, Pittsburgh, Pa.

[2] The rings used are made from clay, molded under pressure, dried and burned. The mix from which the rings are made is as follows:

55 per cent, by weight, of highly refractory flint clay, calcined and ground to pass a 20-mesh sieve and remain on a 60-mesh sieve;

cement.[3] The brick surface enclosed within the ring shall be free from all foreign material.

Preparation of the Slag to be Used as a Solvent.

2. For general use a synthetic slag[4] shall be used as a solvent. This slag shall be ground until it will pass a 40-mesh sieve.

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45 per cent, by weight, of first-quality plastic fire clay ground to pass a 20-mesh sieve.

Approximately 9 per cent by weight of water is added to the above mix and the whole is then thoroughly mixed and finally rubbed through a 10-mesh sieve. The best results are obtained if at this point the mix is allowed to stand for a few days, precaution being taken to prevent evaporation of the water.

The rings are molded in a four-piece steel mold, Fig. 1. The two pieces *A* and *C* engage dowel pins in the base plate. In molding the rings, the various parts are first assembled. The sleeve *B* is then removed and a weighed amount of the prepared ring mix is placed in the space between the parts *A* and *C*, care being taken to spread the mix as uniformly as possible. Experiment will be necessary to determine the weight of clay mix necessary to give the proper sized ring. The sleeve *B* is then replaced and subjected to a downward pressure of approximately 700 lb. per sq. in. The mold is then removed from the press and inverted upon a solid support. The base plate is next taken off and the ring then ejected by pressure upon the parts *A* and *C*. The ring after removal is dried and burned to 1350° C. (2462° F.).

[3] The mix used in cementing the rings on the brick is as follows:

46.5 per cent, by weight, of first-quality fire clay ground to pass a 100-mesh sieve;
46.5 per cent, by weight, of first-quality silica brick ground to pass a 100-mesh sieve;
7 per cent, by weight, of sodium silicate (Baumé 50°).

Sufficient water is added to the above mix to give a sirupy consistency.

The position the ring is to occupy on the brick is first marked by running a pencil around both the inner and outer circumferences of the ring when laid in position, thus outlining the surface of the brick touched by the ring. On this marked surface a coating of the above cement about $\frac{1}{32}$ in. thick is applied with a brush and the ring firmly pressed into place with a circular or twisting motion, while the cement is still soft. If the surface of the brick is rough it may be necessary to coat the lower surface of the ring also before placing it upon the brick.

[4] For general use with this test, a synthetic slag has been developed of the following composition:

Silica (SiO_2)...............	19.00 per cent
Alumina, (Al_2O_3)..........	12.89 "
Iron Oxide (Fe_3O_4)..........	15.73 "
Lime (CaO),...............	33.50 "
Magnesia (MgO)...........	6.93 "
Manganese (MnO);.........	3.52 "
Sodium Oxide..............	8.50 "

Melting Point of above slag.... 1270° C.

The materials as weighed out to give a pound of melted slag are as follows:

Silica......................	72 grams.
Alumina...................	58 "
Ferric Oxide................	80 "
Calicum Carbonate.........	304 "
Magnesium Oxide...........	39 "
Manganese Dioxide.........	24 "
Sodium Carbonate..........	66 "

Any multiple of the above quantity may be used.

Ground silica brick is used as a source of silica. All other materials are c. p. chemicals. All materials should be sufficiently fine to pass a 40-mesh sieve and after being weighed out must be carefully and thoroughly mixed. Melting is performed in a plumbago crucible at a temperature of approximately 1350° C. (2462° F.). The mix should be placed in the crucible before heating.

The slag when melted is poured into a suitable receptacle and cooled. After cooling, the slag is ground and is then ready for use.

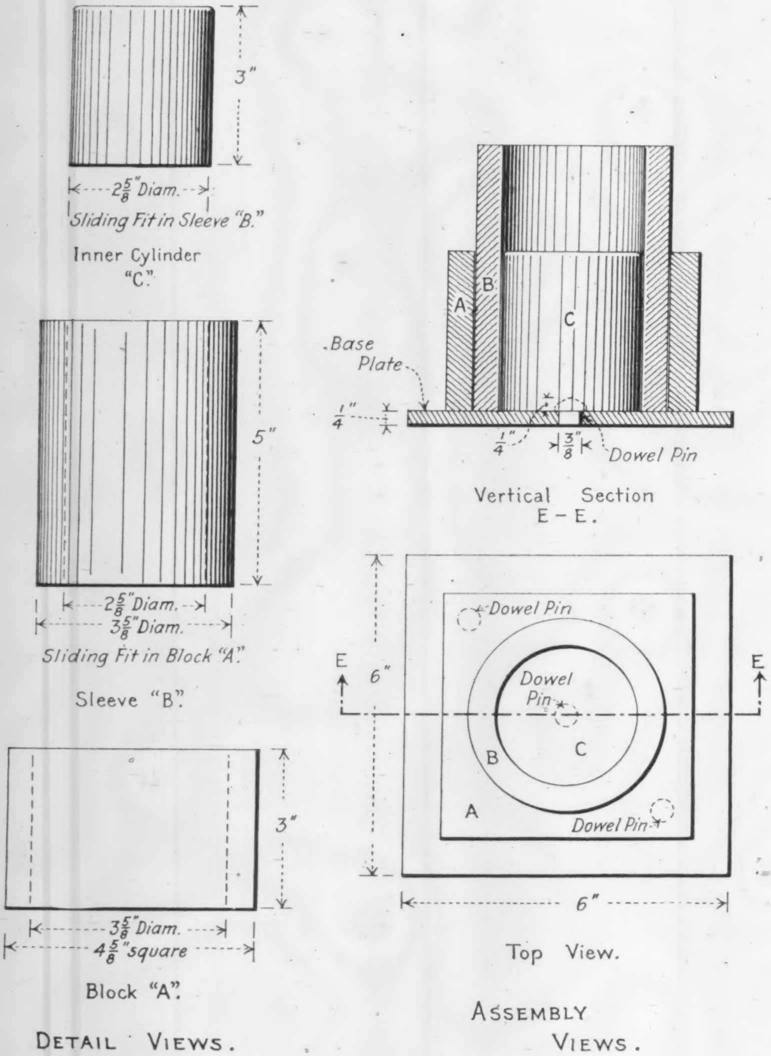
3"
2⅝" Diam.
Sliding Fit in Sleeve "B."
Inner Cylinder "C."
5"
2⅝" Diam.
3⅝" Diam.
Sliding Fit in Block "A."
Sleeve "B."
3"
3⅝" Diam.
4⅝" square
Block "A."
DETAIL VIEWS.
B
A
C
Base Plate
¼"
¼"
⅜"
Dowel Pin
Vertical Section E-E.
Dowel Pin
E
6"
Dowel Pin
E
B
C
A
Dowel Pin
6"
Top View.
ASSEMBLY VIEWS.

FIG. 1.—Mold for Molding Rings.

The Heat Treatment.

3. The bricks shall be placed level on the hearth of a cold furnace and heated to 1350° C. (2462° F), attaining this temperature in a time not less than 5 hours. Thirty-five grams of powdered slag shall then be introduced by a metal spoon or equivalent device, avoiding scattering it upon the sides of the ring. The temperature shall then be held as nearly as possible at 1350° C. (2462° F.), for 2 hours; the fluctuations should not exceed 10° C. (18° F.) above or below this point. The furnace shall then be allowed to cool without removing the bricks. An oxidizing condition shall be maintained in the furnace throughout the test.

Measuring the Penetration.

4. When cold, the brick shall be sawed so that one of the sawed surfaces accurately bisects the center of the rings,[1] but it will be permissible to nick and break the bricks, provided they are broken so that there is no greater variation than $\frac{3}{16}$ in. from either side of a straight line through the center of the rings. The slag will be found to have discolored the brick into which it has penetrated more or less deeply. For measuring the area affected, a planimeter is used. The extreme outer margin of the discolored area shall be traced with the planimeter, closing on the trace of the plane of the original surface of the brick. The area in square inches thus obtained is the area of the brick penetrated and discolored by the slag.

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[1] The wheel used for sawing the brick is a silicon-carbide wheel, 12 in. in diameter, ⅛ in. thick, 1¼ in. diameter of center hole, grit 16. This wheel is known as a vulcanite wheel.

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TENTATIVE TEST
FOR
DETERMINATION OF POROSITY AND PERMANENT VOLUME CHANGES IN REFRACTORY MATERIALS.[1]

Serial Designation: C 20 – 18 T.

This test is issued under the fixed designation C 20; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1918.

Object.

1. The object of this test is to determine the porosity and permanent volume changes in refractory materials when heated to series of specified temperatures.

Preparation of Test Specimens.

2. (*a*) The sample shall consist of at least seven standard-size bricks.

(*b*) Test specimens measuring 2½ by 2½ by 1¼ in. shall be cut so as to remove the original surfaces of the bricks; for this a "cut off" grinding wheel is recommended. There should be five test specimens for each of the seven heat treatments specified in Section 4 or 35 test specimens for each kind of brick. The test specimens shall be brushed or washed free from all adhering dust and marked serially with a refractory stain, for which 5-per-cent cobalt-kaolin mixture is suggested.

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[1] Criticisms of this Tentative Test are solicited and should be directed, preferably before January 1, 1920, to Mr. A. V. Bleininger, Chairman of Committee C-8 on Refractories, Bureau of Standards, Pittsburgh, Pa.

Procedure.

3. After the test specimens have been cut and cleaned, they shall be dried and the volumes and porosity of each obtained as described in Sections 5 and 6. They shall be heated as specified in Section 4, and the changes in volume and porosity determined.

Burning.

4. (*a*) Dry the test pieces prior to placing in the kiln.

(*b*) Raise the temperature as rapidly as is consistent with even heat distribution to 1200° C. From 1200° C. raise the temperature at the rate of 30° per hour, drawing samples at each 50° interval from 1200 to 1500° C.

(*c*) If it is possible and the number of brands being tested warrant, it is best that separate burns to each temperature be made and the kiln sealed and allowed to cool by radiation. In case separate burns cannot be made, the five test specimens from each temperature increment should be covered with hot sand immediately on being drawn; or placed in a supplementary furnace and kept at about 500° C. until all drawings are completed, and then cooled with the furnace sealed to cool wholly by radiation.

Method of Obtaining Data.

5. (*a*) The test specimens shall be cleaned from adhering or loosely attached pieces and particles, care being taken not to alter the exterior volume as originally prepared for this test.

(*b*) The test specimens shall be heated if necessary to 110° C. to remove moisture, and their dry weight (D) obtained to 0.10 g.

(*c*) The test specimens shall be placed in kerosene of known density (δ) under a vacuum of 24 in. for 4 hours at 25° C. and cooled to room temperature while yet immersed.

(*d*) When cool, each test specimen shall be weighed suspended in kerosene at 25° C. to determine its "suspended weight" (S), in grams.

(*e*) The "saturated weight" (W), in grams, of each test specimen shall be obtained immediately after obtaining the suspended weight, by drying lightly with a kerosene-moistened towel to remove the excess kerosene and then weighing in air.

(*f*) The *Exterior Volume* (V), in cubic centimeters, of each test specimen is obtained by subtracting the suspended weight

(S) from the saturated weight (W), and dividing by the density (δ) of the kerosene. Thus,

$$V = \frac{W - S}{\delta} \qquad (1)$$

(g) The *Actual Volume of Open Pores* (V_1), in cubic centimeters, is obtained by subtracting the dry weight (D) from the saturated weight (W), and dividing by the density (δ) of the kerosene. Thus:

$$V_1 = \frac{W - D}{\delta} \qquad (2)$$

(h) The *Apparent Specific Gravity* (T_1) of that portion of the test specimen which is impervious to liquid is obtained by dividing the dry weight by the difference between the dry and suspended weights, and multiplying by the density of the kerosene. Thus,

$$T_1 = \frac{D}{D - S}\,\delta \qquad (3)$$

(i) The *True Specific Gravity* (T) of the wholly solid or burned clay portion is obtained by crushing a portion of the dried test specimen to 120-mesh powder and determining the displacement at 25° C. under 24 in. vacuum, of a 20-g. sample in a 50-cc. straight-wall pyknometer using kerosene, and correcting for density of the kerosene.

(j) The *Volume of Sealed Pores* (V_2), in cubic centimeters, is obtained by subtracting the quotient of dry weight (D) divided by true specific gravity (T) from the volume of the impervious portion of the test specimen; or

$$V_2 = \frac{(D - S)}{\delta} - \frac{D}{T} \qquad (4)$$

(k) The *Volume Shrinkage* is obtained by subtracting the volumes, that is, the values of $\frac{W - S}{\delta}$, before and after the heat treatment.

Basis of Reference for the Data.

6. To show progressive changes in the several volumes, refer all volumes back to the original exterior volume of the test specimen as 100. This is done by multiplying all volumes

by the factor $100/V$, in which V is the exterior volume of the test specimen prior to the subjection to heat treatment.

The volume data should be determined for each test specimen and multiplied by the above factor to reduce all volumes for each test specimen to terms of 100 original exterior volumes of that test specimen before the average of the five for each heat treatment is calculated.

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TENTATIVE TEST
FOR
DETERMINATION OF SOFTENING POINT OF FIRE-CLAY BRICK.[1]

Serial Designation: C 24 – 19 T.

This test is issued under the fixed designation C 24; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

Object.

1. The object of this test is to determine the softening point of fire-clay brick, by comparison of test cones with standard Orton pyrometric cones heated in a suitable furnace.

Preparation of Sample.

2. A 1-kg. (2-lb.) sample shall be taken by chipping off approximately equal portions from the corners of the brick. These fragments shall be reduced in size by means of rolls or a jaw crusher adjusted to pass a lump 6 mm. ($\frac{1}{4}$ in.) in diameter. They shall be mixed thoroughly, and the amount of material reduced to about 250 g. (5 lb.) by quartering. A magnet shall be repeatedly passed through the crushed material until all particles of metallic iron are removed. This portion shall be ground in a porcelain or agate mortar to pass a 60-mesh Standard

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[1] Criticisms of this Tentative Test are solicited and should be directed, preferably before January 1, 1920, to Mr. A. V. Bleininger, Chairman of Committee C-8 on Refractories, Bureau of Standards, Pittsburgh, Pa.

sieve.[1] In order to avoid excessive reduction of the fines, they shall be removed frequently during the process of reduction by throwing the sample on the sieve and continuing the grinding of the coarser particles until all the sample will pass through the sieve.

Preparation of Test Cones.

3. (*a*) The sample thus prepared shall be thoroughly mixed and after the addition of sufficient dextrine or glue and water, shall be formed into test cones in a metal mold in the shape of tetrahedrons measuring 5 mm. ($\frac{3}{16}$ in.) on the sides at the base and 25 mm. (1 in.) high.

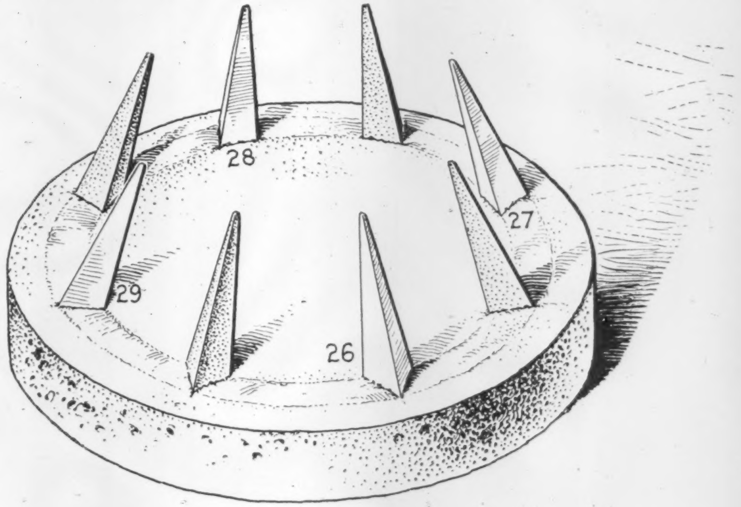

FIG. 1.

(*b*) When dry the test cones may be subjected to a preliminary burn at a temperature not exceeding 1300° C. (2372° F.) for the purpose of sintering them into a firm condition to permit handling.

Mounting.

4. The test cones shall be mounted on plaques of refractory material of such a composition as will not affect the fusibility of the cones.[2] They shall be mounted with the base embedded approximately 1 mm. (0.04 in.) in the plaque and the face of

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[1] Diameter of wire 0.185 mm., opening 0.25 mm.

[2] A mixture of equal parts of a highly refractory clay, such as a good grade of china clay, and fused alumina which will pass a 100-mesh sieve, has been found satisfactory.

one side inclined at an angle of 75 deg. with the horizontal. The arrangement with respect to the Orton cones shall be substantially as shown in Fig. 1, that is, alternating with the Orton cones in such a way that Orton cones of successive numbers will be placed opposite each other. The plaque may be any convenient size and shape and may be biscuited before using, if desired.

Heating.

5. (*a*) The heating shall be done in a suitable furnace at a rate not greater than 15° C. (27° F) per minute, nor less than 10° C. (18° F.) per minute after cone No. 1 is reached, or as nearly within these limits as possible.

(*b*) That type of furnace in which a neutral or oxidizing atmosphere may be maintained is to be preferred. Excessive reducing conditions should be avoided. Care should be taken that the flame does not strike directly against the cone or cone plaque. The furnace should be tested at intervals for the determination of the uniformity of the distribution of the heat.

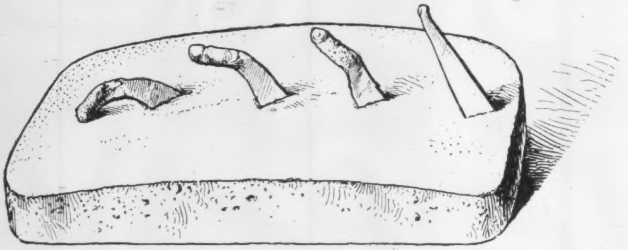

FIG. 2.

Softening Point.

6. (*a*) The softening of the cone will be indicated by the top bending over and assuming the position shown in Fig. 2. The bloating, squatting or unequal fusion of small constituent particles should always be reported. The softening point shall be reported in terms of Orton cones and shall be that cone which most nearly corresponds in time of softening with the test cone. If the test cone softens later than one Orton cone but earlier than the next Orton cone and approximately midway between, the softening point shall be reported thus: Cone No. 31–32.

(*b*) If the test cone starts bending at an early cone but is not down until a later cone, the fact should be reported.

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TENTATIVE METHODS
FOR
CHEMICAL ANALYSIS OF LIMESTONE, LIME AND HYDRATED LIME.[1]

Serial Designation: C 25 – 19 T.

These methods are issued under the fixed designation C 25; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

SOLUTION.

Solution.

The sample, taken and prepared according to the requirements of the specifications for lime of the American Society for Testing Materials,[2] shall be treated as follows:

Weigh out 0.5 g. of the substance and, if a limestone or hydrated lime, ignite in a covered platinum crucible over a strong blast for 15 minutes, or longer if the blast is not powerful enough to effect complete decomposition within that time. Transfer to an evaporating dish, preferably of platinum for the sake of celerity in evaporation, mix to a thin slurry with distilled water, add 5 to 10 cc. of concentrated HCl and digest with aid of gentle heat and agitation until solution is complete.

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1920, to Mr. N. G. Hough, Secretary of Committee C-7 on Lime, 918 G St., N. W., Washington, D. C.

[2] Standard Specifications for Quicklime (Serial Designation: C 5) and for Hydrated Lime (Serial Designation: C 6), 1918 Book of A.S.T.M. Standards. See also Tentative Specifications for Masons' Hydrated Lime (Serial Designation: C 6–19 T), p. 571.

Solution may be aided by light pressure with the flattened end of a glass rod.[1] Then evaporate the solution to dryness, so far as this may be possible on the water bath.

DETERMINATION OF SILICA.

Silica.

Treat the residue, without further heating, at first with 5 to 10 cc. of concentrated HCl, which is then diluted to half strength or less, or pour upon the residue at once 15 to 20 cc. of HCl of half strength. Cover the dish and digest for 10 minutes on the water bath, after which filter the solution and thoroughly wash the separated silica with hot water. Evaporate the filtrate again to dryness, take up the residue without further heating with acid and water, separate the small amount of silica on another filter paper, and wash thoroughly with hot water. Transfer the papers containing the separated residue, wet, to a weighed platinum crucible, dry, ignite (first over a Bunsen burner until the carbon of the filter is completely consumed, then over the blast for 15 minutes) and weigh. Check this weight by further blasting for 10 minutes or as long as may be necessary to secure constant weight. If great accuracy is desired, treat the silica in the crucible with about 10 cc of HF and four drops of concentrated H_2SO_4 and evaporate over a low flame to complete dryness. Finally, blast the small residue for a minute or two, cool and weigh. The difference between this weight, and the weight previously obtained gives the weight of the silica.[2]

DETERMINATION OF IRON OXIDE AND ALUMINA.

Iron Oxide and Alumina.

Make about 250 cc. of the filtrate from the second evaporation for SiO_2 alkaline with NH_4OH, after adding HCl, if necessary, to insure a total volume of 10 to 15 cc. of concentrated HCl, and boil to expel excess of NH_3, or until the odor of NH_3 is barely noticeable. Wash the precipitated iron and aluminum hydroxides, after settling, once by decantation and slightly on the filter using hot water. Setting the filtrate aside, dissolve the precipitate from the paper in hot, dilute HCl, the solution passing into the beaker in which the precipitate was made, and wash the paper thoroughly with hot water. Precipitate the iron and alumina again as above, collect the precipitate on the filter used in the first instance and wash thoroughly with hot water. Then place the filter paper, with the precipitate, in a weighed platinum crucible, and burn off the paper over a low flame. Ignite the precipitate and finally blast 5 minutes (with care to prevent reduction), cool and weigh as $Al_2O_3+Fe_2O_3$.[1]

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[1] If anything remains undecomposed, it should be separated, fused with a little Na_2CO_3, dissolved in dilute HCl, and added to the original solution. A small amount of separated non-gelatinous silica is not to be mistaken for undecomposed matter.

[2] For ordinary control work in the plant laboratory, this correction may, perhaps, be neglected; the double evaporation must never be neglected.

DETERMINATION OF CALCIUM OXIDE.

Calcium Oxide.

Add a few drops of NH_4OH to the combined filtrate from the R_2O_3 precipitate, and bring the solution to boiling. To the boiling solution add 25 cc. of a saturated solution of ammonium oxalate, and continue the boiling until the precipitated CaC_2O_4 assumes a granular form; then allow it to stand 20 minutes, or until the precipitate has settled and the supernatent liquid is clear, filter and wash thoroughly with boiling water. Place the wet filter and precipitate in a platinum crucible, and burn off the paper over the small flame of a Bunsen burner. Ignite the residue, dissolve in hot dilute HCl, and make up the volume of the solution to 100 cc. with water. Add NH_4OH in slight excess and boil the liquid. If a small amount of Al_2O_3 separates, filter it out, wash with boiling water, ignite, weigh and add this weight to that found in the first determination. Then reprecipitate the lime by ammonium oxalate, allow to stand until settled, filter, wash thoroughly with boiling water,[2] and weigh as calcium oxide after ignition and blasting to constant weight in a covered platinum crucible, or determine by solution in dilute H_2SO_4 and titration with standard permanganate.[3]

DETERMINATION OF MAGNESIUM OXIDE.

Magnesium Oxide.

Acidify the combined filtrates from the calcium precipitates with HCl and concentrate on the steam bath to about 150 cc., add 10 cc. of saturated solution of $Na\ (NH_4)\ HPO_4$ and boil the solution for several minutes. Then cool to room temperature, and add NH_4OH drop by drop with constant stirring until the crystallin ammonium-magnesium ortho-phosphate begins to form and then in moderate excess, the stirring being continued for several minutes. Then allow to stand in a cool atmosphere for from 12 to 48 hours,[1] and filter. Dissolve the precipitate in hot dilute HCl, make up the solution with water to about 100 cc., add 1 cc. of a saturated solution of $Na(NH_4)HPO_4$, and NH_4OH drop by drop with constant stirring, until the precipitate is again formed as above described and the ammonia is in moderate excess. Then allow it to stand in a cool atmosphere for from 12 to 48 hours,[1] filter on paper or a Gooch crucible, wash with dilute ammonia containing ammonium nitrate,[2] ignite, cool, and weigh as $Mg_2P_2O_7$.

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[1] This precipitate also contains TiO_2, P_2O_5 and Mn_3O_4.

[2] The volume of wash water should not be large, about 125 cc.

[3] The accuracy of this method admits of criticism, but its convenience and rapidity demand its consideration. For details of method see under "Volumetric Determination of Calcium Oxide."

DETERMINATION OF TOTAL VOLATILE MATTER.

(LOSS ON IGNITION.)

Volatile Matter.

Weigh 1 g. of the properly prepared sample into a weighed platinum crucible, cover with the lid and heat for 5 minutes over a Bunsen burner, starting with a low flame and gradually raising to its full height. Then heat over a blast lamp for 15 minutes, or to constant weight.

DETERMINATION OF MECHANICAL MOISTURE.

Mechanical Moisture.

Weigh 1 g. of the properly prepared sample upon a tared watch glass, and heat in the drying oven (in an atmosphere free from CO_2) at 120° C. for two hours. Cool in a desiccator, and weigh. The loss in weight represents "Mechanical Moisture" or "Hydroscopic Water" at 120° C.

DETERMINATION OF CARBON DIOXIDE.

Carbon Dioxide.

Carbon dioxide is to be determined upon the properly prepared sample according to the method given in U. S. Geologic Survey Bulletin No. 422, page 179. An illustration showing the arrangement of the component parts of the necessary apparatus is shown on page 180 of that Bulletin.

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[1] The less the amount of magnesium present, the longer the precipitate must be allowed to settle.

[2] Made by diluting NH_4OH with distilled water until the solution contains 2½ per cent of NH_3 by weight. Three or four drops of concentrated HNO_3 are then added.

With limestone, use a 0.5-g. sample; with burned lime, hydrated lime, etc., use a 5-g. sample.

Boil the weighed sample with dilute HCl in a small Erlenmeyer flask attached to an upwardly inclined condenser, whence, after passing through a drying system - calcium chloride, anhydrous copper sulfate to retain hydrogen sulfide from decomposable sulfides and any HCl that may pass over, then calcium chloride again — the carbon dioxide is caught by absorption tubes filled with soda-lime followed by calcium chloride. Of course, arrangement is made for a current of CO_2 free air with which to sweep out the apparatus before and after the experiment, and for a slow current during its continuance.

The results are very accurate and the determination can be quickly carried out.

The manipulations are as follows: Pour hot water upon the powder in the flask fitted with a separatory funnel and delivery tube; attach this to the condenser, and force a current of CO_2 free air through the whole system, except the weighed absorption tubes, until the original air has been displaced, the observation bulbs (Mohr Potash Bulbs containing sulfuric acid to show the rate of gas flow) being attached directly to the drying system. Then close the stop-cock in the separatory funnel, half fill the latter with HCl (1:1), replace the rubber stopper of the funnel, insert the absorption tubes between the drying system and the observation bulbs, and allow the acid to flow into the flask, slowly if there is much carbon dioxide, rapidly if there is but little. When effervescence diminishes in the former case, at once in the latter, light the burner under the flask and start the flow of water through the condenser. Keep the flame low, so as to secure steady but quiet ebullition, and do not interrupt the gas current although it should be reduced to a slow rate. With much carbon dioxide the rate of absorption is very readily noted by holding the hand to the soda-lime tubes, which become hot or warm where absorption is taking place. Sufficient time having elapsed, extinguish the flame, and increase the air current. When cool, disconnect the soda lime tubes from the apparatus and allow to stand in the balance case until two weights taken 30 minutes apart agree within 0.5 mg.

The soda lime for use in this determination must be porous, not hard and unabsorptive like that sometimes used for the combustion of nitrogenous organic substances.

DETERMINATION OF SULFURIC ANHYDRIDE.

Sulfuric Anhydride.

Weigh 2 g. of the properly prepared sample into a small, dry beaker and stir it up with 10 cc. of cold water until all lumps are broken up and the lighter particles are in suspension. Add 15 cc. of dilute HCl (1:1) and heat until solution is complete. Filter through a small paper and wash the residue thoroughly with hot water. Dilute the filtrate to 250 cc., heat to boiling, and add 10 cc. of a boiling 10-per-cent solution of barium chloride. Stir well and allow to stand over night. Filter, wash with boiling water, ignite and weigh as $BaSO_4$.

SEPARATION OF IRON AND ALUMINA.

Separation of Iron and Alumina.

Fuse the combined iron and aluminum oxides in a platinum crucible at a very low temperature with 3 to 4 g. of $KHSO_4$, or better $NaHSO_4$,[1] take up the melt with so much dilute H_2SO_4 that there shall be present no less than 5 g. absolute acid and enough water to effect solution on heating. Then evaporate the solution and eventually heat until acid fumes come off copiously. After cooling and redissolving in water, filter out the small amount of silica, wash, ignite, weigh, and correct by HF and H_2SO_4.[2] Reduce the filtrate by zinc, or preferably by H_2S, boiling out the excess of the latter afterwards while passing CO_2 through the flask, and titrate with permanganate.[3] The strength of the permanganate solution should not be greater than 0.0040 g. Fe_2O_3 per cubic centimeter. Subtract the weight of Fe_2O_3 obtained by this method from the total weight of the R_2O_3 precipitate, and report the remainder as Al_2O_3.

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[1] Or the corresponding pyrosulfates which are less troublesome and more effective than the acid sulfates.

[2] This correction for SiO_2 should not be made when the HF correction of the main silica determination has been omitted, unless that silica has been obtained by only one evaporation and filtration. After two evaporations, 1 to 2 mg. of silica are still to be found with the R_2O_3 precipitate.

[3] In this way only is the influence of titanium to be avoided and a correct result obtained for iron.

VOLUMETRIC DETERMINATION OF CALCIUM OXIDE.

Volumetric Determination of Calcium Oxide.

Make the filtrate from the iron and alumina precipitate alkaline with ammonia, boil, and add 25 cc. of a boiling saturated solution of ammonium oxalate.[1] Stir vigorously and allow to stand 15 minutes or until the precipitate has settled, filter on an 11-cm. paper, and wash ten times with hot water.[2] Transfer paper and precipitate to the beaker in which the precipitation was made, spreading the paper out against the upper portion of the beaker. Wash the precipitate from the paper with a jet of hot water, fold the paper and leave it adhering to the upper portion of the beaker. Add to the contents of the beaker, 50 cc. of dilute H_2SO_4 (1:10), dilute to a volume of 150 cc. and heat to a temperature of 80–90° C. Titrate with the standard permanganate solution (see following directions) until the pink end point is obtained. Now drop the folded filter paper (which has been adhering to the side of the beaker) into the liquid; the pink color of the latter will be discharged. Finish the titration by adding permanganate, a drop at a time, until the pink end point is again obtained. From the total quantity of standard permanganate solution used, calculate the percentage of calcium oxide.

PREPARATION OF STANDARD SOLUTION OF POTASSIUM PERMANGANATE.

Prepare a solution of potassium permanganate containing 5.64 g. of the pure crystallized salt in each liter. Such a solution will be of such strength that 1 cc. will approximately equal 0.005 g. of CaO.

The best and simplest way to prepare such a solution is to weigh out the required quantity of potassium permanganate and place in a bottle containing the proper volume of water a week or ten days before the solution is to be standardized. The bottle and its contents must be kept in a dark place and shaken every few hours for the first three or four days. When ready for standardization, siphon off the solution through a glass siphon into another bottle, leaving a depth of about one inch of solution in the original bottle.[1] Thoroughly mix the solution in the second bottle by shaking and standardize.[2]

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[1] It is better to use 3 grams of crystallized ammonium oxalate dissolved in 40–50 cc boiling water immediately before using.

[2] Use only 100–125 cc. water for this washing.

Dissolve 0.5 g. of sodium oxalate[3] in a 400-cc. beaker with 200 to 250 cc. of hot water (80–90° C.) and add 10 cc. of dilute H_2SO_4 (1:1) to the solution. Titrate at once with the permanganate solution being standardized, stirring vigorously and continuously. The permanganate solution must not be added more rapidly than 10 to 15 cc. per minute, and the last 0.5 to 1 cc. must be added dropwise, with particular care to allow each drop to be fully decolorized before the next is introduced. The excess of permanganate solution necessary to give the end point color is determined by running a blank determination in another beaker containing the same volume of acid and water present in the original beaker, and heated to the same temperature.[4] The value of the permanganate solution in grams of CaO per cubic centimeter of solution may be calculated from the following equations:

$$Na_2C_2O_4 + H_2SO_4 = Na_2SO_4 + H_2C_2O_4.$$

$$5\ H_2C_2O_4 + 2\ KMnO_4 + 8\ H_2SO_4 = 5\ H_2SO_4 + K_2SO_4 + 2\ MnSO_4 + 10\ CO_2 + 8\ H_2O.$$

$$5\ CaC_2O_4 + 2\ KMnO_4 + 8\ H_2SO_4 = 5\ CaSO_4 + K_2SO_4 + 2\ MnSO_4 + 10\ CO_2 + 8\ H_2O.$$

BLANK DETERMINATIONS.

In making chemical analysis of limestone, etc., by any of the above methods, blank determinations should be made on all reagents and the necessary corrections made in calculating the final results.

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[1] The siphon should not extend nearer than one inch from the bottom of the original bottle.

[2] This solution should be standardized at least once every week. It will be found more convenient to make a solution as above described and standardize it every week, than to attempt, by boiling and filtering, to make a solution which will not change.

[3] Sodium oxalate for standardization of potassium permanganate solution should be purchased from the U. S. Bureau of Standards, Washington, D. C. This material is sold by the Bureau as Standard Sample No. 40.

[4] When the end point is reached, the temperature of the solution should not be below 60° C.

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TENTATIVE METHODS
FOR
ULTIMATE CHEMICAL ANALYSIS OF REFRACTORY MATERIALS.[1]

Serial Designation: C 18 – 18 T.

These methods are issued under the fixed designation C 18; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917; REVISED, 1918.

Prefatory Note.—It will be understood that the making of a complete silicate analysis is a difficult procedure requiring a wide knowledge of the chemistry involved in the operations, and a thorough training in carrying out the work. A skilled analyst of good training is therefore required to do the work. The descriptions here given cover the vital points of procedure, but frequent reference in regard to the details of the various manipulations must be made to *Bulletin No. 422*, United States Geological Survey on "Analysis of Silicate and Carbonate Rocks," by W. F. Hillebrand; also, to "Treatise on the Ceramic Industries," Vol. 1 (1913), by J. W. Mellor; and to similar publications.

I. GENERAL CONSIDERATIONS.

Grinding of Sample.

1. The sample shall be crushed in a hardened tool-steel mortar, using a pestle of the same sort. Fine grinding shall be done in an agate mortar, either by hand, or by a mechanical sample grinder of the McKenna, Carling or similar type, so constructed as to prevent the introduction of impurity.

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1920, to Mr. A. V. Bleininger, Chairman of Committee C-8 on Refractories, Bureau of Standards, Pittsburgh, Pa.

Statement of Analysis.

2. Moisture shall be determined in the sample in its ordinary air-dried condition, and all other percentage compositions shall be calculated to a moisture-free basis. Whenever a sample is weighed out for any determination, a moisture determination shall also be made. If preferred, the sample may be dried in a weighing bottle, from which the required samples shall be weighed out.

Checking Results.

3. In all cases, check determinations shall be made, and the results shall be redetermined if satisfactory checks are not obtained. It shall be considered satisfactory if the differences between check determinations do not exceed the following limits:

For silica or other constituent amounting to 30 per cent or over	0.3 per cent
For alumina or other constituent amounting to 10–30 per cent	0.2 per cent
For any other constituent amounting to under 10 per cent	0.1 per cent

These figures are stated in terms of the whole sample as 100 per cent.

II. SOLUTIONS REQUIRED.

Concentrated Acids.

4. The acids referred to as concentrated shall be of approximately the following specific gravities:

Hydrochloric Acid (HCl)	1.20
Sulfuric Acid (H_2SO_4)	1.84
Nitric Acid (HNO_3)	1.42

Ammonium Carbonate.

5. Dissolve 1.5 g. of ammonium carbonate in 50 cc. of cold water.

Ammonium Chloride.

6. Dissolve 107 g. of NH_4Cl in 1000 cc. of warm water.

Ammonium Nitrate.

7. Neutralize 20 cc. of concentrated HNO_3 with NH_4OH and dilute to 1000 cc. Test with litmus; the solution shall not be acid.

Ammonium Oxalate.

8. Dissolve 1 g. of ammonium oxalate in 50 cc. of water, heating gently.

Standard-Titania Solution.

9. The strength of the final standard titania solution shall be 1 cc. = 0.0001 g. TiO_2. To prepare the solution weigh out in

a platinum crucible an amount of potassium titanium fluoride (K_2TiF_6) sufficient to make from ½ to 1 liter of "stock solution" in which 1 cc. = 0.001 g. TiO_2. Evaporate several times with H_2SO_4 without taking to dryness, thus driving out all fluorine. Take up the residue with water containing enough H_2SO_4 to make at least 5 per cent of the solution, when finally diluted to the standard solution strength. To standardize the stock solution take out two 50-cc. portions, dilute, boil and precipitate with ammonia. Filter, wash with hot water until free from alkali, ignite, blast and weigh. The duplicate should check very closely. From the weight of titania thus determined calculate the strength of the stock solution. The standard solution to be used is obtained from the stock solution by diluting until 1 cc. = 0.0001 g. (TiO_2).

Standard Potassium-Permanganate Solution.

10. Dissolve about 0.4 g. (a little less) of $KMnO_4$ in 1 liter of water and check against an iron solution of known purity and strength. Dilute the solution until 1 cc. = 0.001 g. Fe_2O_3

The ordinary chemical iron wire is not sufficiently pure for this use. If preferred the solution may be standardized against sodium oxalate, a pure form of which is prepared especially for such work by the U. S. Bureau of Standards, Washington, D. C.

III. METHODS.

MOISTURE.

Moisture.

11. To determine moisture, heat approximately 1 g. of the sample at a temperature not under 105 nor over 110° C., to constant weight.

IGNITION LOSS.

Ignition Loss.

12. To determine loss on ignition, heat about 1 g. of the sample over a blast lamp or in an electric furnace at 900 to 1000° C., to constant weight. Ignition loss may be determined in the sample from which the moisture has been removed. The percentage of ignition loss is calculated to a moisture-free basis.

SILICA.

Silica.

13. To determine silica, weigh out approximately 0.5 g. of the sample and mix with 5 g. of Na_2CO_3. Put a little Na_2CO_3 in the bottom of the crucible before introducing the mixture, and

then cover the mixture with a little more Na_2CO_3. Fuse over a Meker burner or blast lamp until complete solution is obtained. Cool the fusion and as it solidifies, rotate the crucible to spread the mass up the side walls. Dissolve the fusion in about 100 cc. of water in a platinum or porcelain evaporating dish. Add about 20 cc. of concentrated HCl, introducing it slowly by means of a pipette, keeping the dish covered with a watch glass. Evaporate to dryness and heat until the fumes of HCl are gone. Add about 5 cc. of concentrated HCl and 30 to 40 cc. of water. Warm on a water bath for 10 to 15 minutes and break up the lumps. Decant the clear liquid onto a filter paper and collect the filtrate in a 400-cc. beaker. Add more HCl and water to the evaporating dish, warm again and decant. Repeat this a third time.

Finally transfer the contents of the dish to the filter paper. Wash with cold water until silver nitrate shows no chlorides to be left. Transfer the filtrate to the original evaporating dish, evaporate again to dryness, take up with a little HCl and water, transfer to a new filter paper and wash as before. Transfer both silica precipitates to a platinum crucible. Ignite carefully over a Bunsen flame until the filter paper is burned off, then blast for about 30 minutes; cool and weigh. Repeat blasting for 5 minutes, weigh again and repeat until constant weight is obtained.

To the residue in the crucible add about 5 cc. of water and 5 drops of H_2SO_4. Add HF drop by drop at first, and then slowly until the crucible is almost one-half filled. Warm on a hot plate until almost dry, add 2 or 3 cc. more of HF and evaporate to dryness. Heat the crucible to bright redness and then blast for 5 minutes. Cool and weigh and repeat blasting to constant weight. The loss in weight from the original silica residue represents the actual silica content (SiO_2), except for that part of silica which is later recovered from alumina, etc. The residue from the HCl evaporation is left in the crucible and the total precipitate of alumina, etc., is added to this same crucible in which it is ignited and weighed.

ALUMINA.

Alumina. 14. Regarding the determination of alumina, reference should be made to *Scientific Paper No. 286* of the U. S. Bureau of Standards by Dr. Blum on "Determination of Alumina as Oxide"

To determine alumina, to the filtrate from the silica determination, add about 10 cc. of NH_4Cl solution and heat to boiling. Then add NH_4OH very slowly and with constant stirring until there is a slight excess. The NH_4OH must be free from CO_2. Filter hot and rapidly, and wash four times by decantation with hot solution of ammonium nitrate. Carefully wash the precipitate from the filter paper into a beaker, using hot water. Dissolve the precipitate in hot dilute HCl. Repeat the precipitation with NH_4Cl and NH_4OH. Decant four times as before, using hot ammonium nitrate. Transfer to the filter paper and wash with hot ammonium nitrate until the washings are free from chlorides when tested by silver nitrate. Evaporate the filtrate nearly to dryness, add a little NH_4OH and continue the evaporation. Keep the solution alkaline to coagulate any iron and aluminum hydroxides. Transfer the precipitate to a filter paper and wash thoroughly. Transfer the moist filter paper to the platinum crucible containing the residue from the silica. Burn off the filter paper and blast the precipitate. Repeat blasting and weighing to a constant weight.

IRON OXIDE.

Iron Oxide.

15. To determine iron oxide, fuse the ignited alumina precipitate with about six times its weight of potassium pyrosulfate or potassium bisulfate. Avoid sputtering. Heat carefully to redness and continue heating until the residue is all dissolved. Cool. Dissolve in warm water and add about 10 cc. of dilute H_2SO_4 (1:5). Evaporate to a small volume. Then heat to a higher temperature until copious fumes of H_2SO_4 are evolved. Sufficient H_2SO_4 should be present to form a pasty mass when cooled. Take up with water, filter off, wash, ignite and weigh the silica as before and evaporate with HF as before. The loss in weight is extra silica to be added to the original silica determination and subtracted from the alumina. Fuse the residue with a little potassium pyrosulfate or potassium bisulfate, and add the solution of this cake to the main solution. Transfer the total filtrate to a 250-cc. graduated flask and dilute to 250 cc. ,mixing thoroughly. Draw off 50 cc. of this solution and reserve for titania determination. Pass the remaining 200 cc. through a Jones reductor, or other-

wise reduce the solution with pure zinc and H_2SO_4. To the solution add 3 cc. of 10-per-cent $CuSO_4$ solution and titrate with standard $KMnO_4$ solution (1 cc. equivalent to 0.001 g. Fe_2O_3), until a faint pink tinge is seen. If Jones reductor or similar apparatus is used, subtract the $KMnO_4$ equivalent, which has previously been determined on blank samples run through the apparatus. From the result, calculate the iron as Fe_2O_3.

TITANIA.

Titania. 16. To determine titania, place in a small Nessler tube the 50 cc. of filtrate previously set aside for titania determination, and fill the tube up to the graduation mark. Add 1 cc. of H_2O_2 (free from fluorine) and shake well. The color of this solution is now compared in any standard color comparator with the color of a known standard solution, preferably of such strength that 1 cc. equals 0.0001 g. of titanium dioxide (TiO_2). To make the comparison, put 10 cc. of this standard solution into a second small Nessler tube and dilute with water from a burette until the color is matched. Note the amount of water added and calculate the percentage of TiO_2 in the sample.

LIME.

Lime. 17. To determine lime, evaporate the filtrate from the alumina precipitation to about 250 cc. While still boiling add about 5 cc. of acetic acid. Meanwhile, dissolve about 1 g. of oxalic acid in a little hot water and add to the solution. In about 5 minutes add a slight excess of NH_4OH and boil until precipitation is complete. Cool thoroughly and filter. Wash three times by decantation with dilute NH_4OH (1 : 10) or a 1-per-cent solution of ammonium oxalate. Dissolve the precipitate by adding about 50 cc. of dilute HNO_3 (1 : 5). Again add a slight excess of NH_4OH and a few drops of oxalic-acid solution. Boil well and let stand a couple of hours to cool. Filter and wash as before. Transfer the precipitate to a platinum crucible, carefully burn off the paper and ignite over a blast lamp for about 10 minutes. Cool and weigh quickly. Repeat the blasting to constant weight. The increase in weight of crucible is calcium oxide.

MAGNESIA.

Magnesia.

18. To determine magnesia, add to the filtrate from lime precipitation about 2 g. of sodium-ammonium-phosphate dissolved in 15 cc. of water. Stir vigorously and while stirring add drop by drop about one-third of the volume of the solution of NH_4OH. Let stand 12 to 24 hours. Filter and wash the precipitate with dilute NH_4OH (1 : 10). Discard the filtrate. Wash the precipitate until the washings show no discoloration when tested with silver nitrate. Redissolve the precipitate in warm dilute HNO_3 (1 : 5), using about 50 cc., and collect in a beaker. Precipitate and wash as before. Collect the precipitate on a Gooch asbestos crucible. Dry slowly and then heat over a Meker burner for about 10 minutes; cool and weigh. Re-ignite to constant weight.

The $Mg_2P_2O_7$ is never pure, being contaminated by small amounts of calcium, barium, aluminum, iron, manganese, etc., but in the analysis of refractories this error is negligible, and correction for these impurities is not required unless previously agreed upon.

ALKALIES.

Alkalies.

19. To determine alkalies, the J. Lawrence Smith method shall be used. Weigh out about 0.5 g. of the sample and mix well with 0.5 g. of NH_4Cl and 3 g. of $CaCO_3$. Transfer to a platinum crucible, placing about 0.5 g. of $CaCO_3$ in the bottom of the crucible and a similar amount over the top of the mixture. Heat gently over a low flame for about 15 minutes to volatilize NH_4Cl. Then raise the temperature until the lower three-quarters of the crucible is dull red. Hold this temperature for about one hour. Cool, take up with about 50 cc. of water and heat over a water bath, adding water to replace that lost by evaporation. Break up any lumps with a small pestle. Decant the clear liquid through a filter paper and wash four times by decantation. Then transfer the residue to the filter. Wash until silver nitrate shows only a very faint turbidity. To the filtrate add NH_4OH and ammonium carbonate and heat to boiling. Filter and again digest the precipitate with NH_4OH and ammonium carbonate. Filter and allow the filtrate to collect with the previous filtrate, then evaporate to dryness in a plat-

inum or porcelain dish. Remove ammonium salts by gentle ignition in a moving flame. Treat with water and remove the last trace of lime by adding ammonium oxalate to the boiling solution and let stand over night. Filter, evaporate to dryness, ignite gently and allow to cool. Then moisten the residue with HCl, evaporate again to dryness, ignite gettly and weigh. Dissolve in water. Ignite and weigh any insoluble residue, deducting this from the alkali chlorides.

Dilute the solution of the mixed chlorides and add hydrochloroplatinic acid in amount equal to 0.3 cc. more than would be necessary if all chlorides were present as NaCl. Evaporate to a syrupy consistency. Cool and treat with a few cubic centimeters of 80-per-cent ethyl alcohol. Stir and decant through a weighed Gooch crucible. Treat again with 80-per-cent alcohol and decant. Repeat washing and decantation until the alcohol leaving the Gooch crucible is colorless and the precipitate appears golden yellow, not orange. Transfer the precipitate to the Gooch crucible, wash with 80-per-cent alcohol about six times and dry at 130° C. to constant weight. This residue is potassium chloroplatinate.

The oxides are calculated as follows:

Weight of potassium chloroplatinate $\times 0.3068 = KCl$.
Weight of potassium chloroplatinate $\times 0.1941 = K_2O$.
Total chlorides $- KCl = NaCl$.
$NaCl \times 0.5303 = Na_2O$.

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TENTATIVE METHODS
FOR
TESTS OF GYPSUM AND GYPSUM PRODUCTS.[1]

Serial Designation: C 26 – 19 T.

These methods are issued under the fixed designation C 26; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

I. DETERMINATION OF FREE WATER FOR RAW UNCALCINED GYPSUM ONLY.

Free Water.

1. (*a*) Not less than 1 lb. of the entire sample as received shall be weighed, spread out in a thin layer in suitable vessel, placed in a drying oven, and dried at 60° C. for 2 hours. It shall then be cooled in an atmosphere free from moisture, and weighed again. The loss of weight corresponds to the free water, and shall be calculated to percentage of sample as received.

(*b*) The dried sample shall be stored in an air-tight container until used.

II. DETERMINATION OF FINENESS.

Fineness.

2. Fineness shall be determined by screening a known weight of the dried sample through screens of the specified sizes and weighing the amount of material retained on each screen. The

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1920, to Mr. V. G. Marani, Secretary of Committee C-11 on Gypsum, 111 W. Monroe St., Chicago, Ill.

material shall be shaken through the screen with as little abrasion as possible.

The size of the sample to be used in this determination shall depend upon the size of grain of the sample. If the sample will all pass the $\frac{1}{4}$-in. screen, 100 g. will be sufficient; if the largest particles are more than 1 in. in diameter, at least 1000 g. must be used. With these limitations the size of sample to be used is left to the discretion of the operator.

NOTE.—The sizes of the screens to be used are given in the Tentative Specifications for Gypsum (Serial Designation; C 22 – 19 T), for Calcined Gypsum (Serial Designation: C 23 – 19 T) and Tentative Report on Gypsum Plasters of the American Society for Testing Materials, covering the particular product examined.[1]

III. CHEMICAL ANALYSIS OF RAW OR CALCINED GYPSUM.

Preparation of Sample.

3. Grind about 10 g. of the material, dried as in Section 1, in mortar and pestle, using extreme care that the material is not unduly exposed to the action of moisture in the air or overheating. Grind the sample until it all passes a 100-mesh sieve, and keep it in an air-tight container until ready for use.

Combined Water.

4. Place 1 g. of the sample prepared as described in Section 3 in a covered crucible and dry at 215 to 230° C. to constant weight. Calculate the loss of weight to percentage of sample as received and reported as combined water.

Carbon Dioxide.

5. Place the residue obtained after drying, as described in Section 4, in a suitable flask and dissolve it in dilute HCl (not stronger than 1 : 4) in such a way that the gas evolved can be collected in either soda lime or caustic potash and weighed. The solution shold be boiled for one minute, and a current of CO_2-free air kept passing through the apparatus for $\frac{1}{2}$ hour. The increase of weight of the soda lime or caustic potash corresponds to the weight of carbon dioxide, which is to be calculated to percentage of sample as received.

Silica.

6. Place 0.5 g. of the sample prepared as described in Section 3 in a porcelain casserole. Add about 25 cc. of 1:5 HCl, and evaporate to apparent dryness on hot plate. Cool and add enough concentrated HCl to wet thoroughly. Add about 10 c.c of water, boil, filter, and wash. Put the filtrate back in the same casserole. Evaporate it to dryness and heat to about 120° C.

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[1] See pp, 575–580 and 331–347.

for one hour. Cool. Add enough concentrated HCl to wet thoroughly. Add about 10 cc. of water, boil, filter, and wash. Transfer the two precipitates to the same crucible, ignite, and weigh. Calculate this weight to percentage of sample as received.

Iron and Alumina.

7. To the filtrate obtained as described in Section 6, add a few drops of HNO_3 and boil to insure oxidation of the iron. Add 2 g. of NH_4Cl previously dissolved in water. Make alkaline with NH_4OH. Digest hot for a few minutes until the precipitate coagulates. Filter, wash, ignite the precipitate and weigh as $Fe_2O_3+Al_2O_3$. Calculate this weight to percentage of sample as received. This precipitate may be further treated to separate the two oxides, but this is generally unnecessary.

Lime.

8. (*a*) To the filtrate obtained as described in Section 7, add 5 g. of $(NH_4)_2C_2O_4$ dissolved in water. Digest hot for $\frac{1}{2}$ hour, making sure that the solution is always alkaline with NH_4OH. Filter, wash and ignite in a platinum crucible over a strong blast to constant weight. Calculate this weight to percentage of sample as received.

(*b*) *Alternative Method.*—To the filtrate obtained as described in Section 7, add 5 g. of $(NH_4)_2C_2O_4$ dissolved in water. Digest hot for $\frac{1}{2}$ hour, making sure that the solution is always alkaline with NH_4OH. Filter and wash. Transfer the precipitate to a beaker, and wash the filter paper with hot dilute H_2SO_4, catching the washings in the same beaker. Heat gently to complete solution, adding more H_2SO_4 if necessary. While still warm, titrate with a solution of $KMnO_4$ containing 5.6339 g. per liter, until the pink color is permanent. The number of cubic centimeters of $KMnO_4$ used gives directly the percentage of lime in the dried sample. Recalculate to percentage of sample as received.

Magnesia.

9. To the filtrate obtained as described in Section 8 (*a*) or (*b*), add enough water to give a total volume of about 600 cc. Cool. Add 10 cc. of NH_4OH and 5 g. $NaNH_4HPO_4$ dissolved in water. Stir until precipitate begins to form. Let stand over night. Filter, wash with a 2-per-cent solution of NH_4NO_3. Ignite and weigh. Multiply this weight by 40/111 to find the weight of MgO. Then calculate to percentage of sample as received.

Sulfur Trioxide.

10. Dissolve 0.5 g. of the sample prepared as described in Section 3 in 50 cc. of 1 : 5 HCl. Boil. Add 100 cc. of boiling water, and continue boiling for 5 minutes. Filter immediately and wash thoroughly with hot water. Boil, and while boiling, add slowly 20 cc. of a boiling 10 per cent solution of $BaCl_2$. Digest hot for one hour, until precipitate settles. Filter and wash. Dry carefully. Ignite over Bunsen burner at lowest heat possible until filter paper is burned off. Ignite at bright red heat for 15 minutes, and weigh. Multiply this weight by 80/233 to determine the weight of SO_3. Then calculate to percentage of sample as received.

Sodium Chloride.

11. Dissolve a 1-g. sample prepared as described in Section 3 in boiling water, add two or three drops of potassium-chromate solution and titrate with an N/20 solution of silver nitrate. Each cubic centimer of silver nitrate solution = 0.002923 g. of sodium chloride. Calculate to percentage of sample tested.

Calculation of Results.

12. By the methods given above, the results are obtained and reported in the following form:

	Per cent.
Free Water	
Combined Water	
Silicia and insoluble, SiO_2	
Iron and alumina, R_2O_3	
Lime, CaO	
Magnesia, MgO	
Sulfur Trioxide, SO_3	
Carbon Dioxide, CO_2	
Sodium Chloride, NaCl	
	100.00 ±

NOTE.

Since it is frequently advisable to recalculate these results, that they may be more enlightening, the following method is submitted for consideration:

(*a*) Multiply percentage of MgO by 84/40, to find percentage of $MgCO_3$.

(*b*) Multiply the percentage of MgO by 44/40 to find the percentage of CO_2 as $MgCO_3$.

(*c*) Deduct CO_2 as $MgCO_3$ from the CO_2 determined.

(*d*) Multiply the CO_2 remaining by 100/44 to find percentage of $CaCO_3$.

(*e*) Add together the percentage of SiO_2, R_2O_3, $MgCO_3$, and $CaCO_3$, and report as percentages of "Impurities."

(*f*) Multiply the percentage of $CaCO_3$ by 56/100 to find the percentage of CaO as $CaCO_3$.

(*g*) From the total percentage of CaO, deduct the percentage of CaO as $CaCO_3$. The remainder may be called "available CaO."

(*h*) The "available CaO" should bear to the SO_3 a ratio of 7 to 10. Determine which (if either) is in excess.

(*i*) If the CaO is in excess, multiply the SO_3 by 7/10, and subtract the result from the "available CaO." The remainder is reported as "excess CaO."

(*j*) If the SO_3 is in excess, multiply the "available CaO" by 10/7 and subtract the result from the SO_3. The remainder is reported as "excess SO_3."

(*k*) Add together the "available CaO," and the SO_3, and subtract the "excess CaO" or "excess SO_3." The remainder is $CaSO_4$.

(*l*) If the $CaSO_4$ is present as $CaSO_4 \cdot \frac{1}{2}H_2O$, the percentage of $CaSO_4$ should bear to the percentage of water a ratio of 136 to 9. Determine which (if either) is in excess.

(*m*) If the $CaSO_4$ is in excess some of it is present in the anhydrous form. Multiply the percentage of combined water by 136/9 to find the percentage of $CaSO_4$ as $CaSO_4 \cdot \frac{1}{2}H_2O$. The difference between the total $CaSO_4$ and the $CaSO_4 \cdot \frac{1}{2}H_2O$, is the $CaSO_4$ in the anhydrous form.

(*n*) If the water is in excess, some of the $CaSO_4$ is present as gypsum. Let x = percentage of $CaSO_4 \cdot \frac{1}{2}H_2O$, and y = percentage of $CaSO_4 \cdot 2H_2O$. Then $x+y$ = percentage of $CaSO_4$ (as found in *k*) + percentage of water.

$$\frac{9x}{136} + \frac{36y}{172} = \text{percentage of combined water.}$$

Solve these equations for x and y. Report x as percentage of "calcined gypsum," $CaSO_4 \cdot \frac{1}{2}H_2O$. Report y as percentage of gypsum, $CaSO_4 \cdot 2\,H_2O$.

Having made these calculations, the result may be reported as follows:

	Per cent.
Gypsum, $CaSO_4+2H_2O$	
Calcined gypsum, $CaSO_4+\frac{1}{2}H_2O$	
Anhydrite, $CaSO_4$	
Excess CaO or Excess SO_3	
Sodium chloride, NaCl	
Other ingredients	
	100.00 ±

The presence of the different forms of $CaSO_4$ should be corroborated by a microscopic examination.

IV. MICROSCOPIC EXAMINATION OF RAW OR CALCINED GYPSUM.

Microscopic Examination.

13. The microscopic examination of gypsum products presupposes a thorough knowledge of petrography and the

developments in technique in this field. The distinctions between substances depend on their optical and crystallographic properties, so that when the individual crystallites of substances are minute, and above all when they possess similar properties, the microscopic examination leads at best to only qualitative results. It is, however, of great value in conjunction with the chemical analysis, since it furnishes proof of the state of combination of the radicals determined by chemical means.

The compounds met with in an examination of gypsum products are gypsum (with impurities which may consist of clay, quartz, or calcium carbonate), $CaSO_4 \cdot \frac{1}{2}H_2O$, soluble anhydrite, insoluble anhydrite, lime and calcium hydroxide. Other siliceous, argillaceous and organic materials are frequently present as added foreign material, but their compositions and properties are variable and hence it is not within the scope of these methods to discuss them.

Gypsum.

14. *Gypsum* ($CaSO_4 \cdot 2H_2O$) is noted in two varieties, selenite and alabaster, of which only the latter is of importance in the manufacture of gypsum products. It is noted in small grains, which may be irregular and may also show an attempt at prismatic development. Twinning may also be observed, the extinction is inclined and large extinction angles are noted. The indices of refraction for sodium light are $\alpha = 1.521$, $\beta = 1.523$ and $\gamma = 1.530$. The double refraction ($= 0.009$) is fairly weak and first order white to yellow interference colors are generally observed. The plane of the optic axis is parallel to *b* (010). The optical character is positive and the dispersion for red is greater than that for violet.

The impurities are often clay, $CaCO_3$, or silica. Clay is a very indefinite term applied to certain hydrous silicates of alumina, of which kaolin is the most important. Kaolin may be distinguished from gypsum by its higher indices ($\beta = 1.55$). Amorphous clay material may be distinguished by its isotropy with crossed nicols. Quartz has a higher index than gypsum ($\epsilon = 1.553$; $\theta = 1.544$) and is uniaxial, optically positive. Calcite is easily distinguishable by its extremely high double refraction, giving rise to a white of the higher order interference color. Furthermore, it is uniaxial, optically negative.

Plaster of Paris.

15. *Plaster of Paris* consists of either $CaSO_4 \cdot \frac{1}{2}H_2O$ or soluble anhydrite, or mixtures of both.

(*a*) $CaSO_4 \cdot \frac{1}{2}H_2O$ is observed in very minute prism crystallites which are extremely intergrown. These crystallites apparently are not twinned in any definite manner, but are found in aggregates, the boundaries of which are those of the original gypsum crystals, and the small crystallites are orientated more or less parallel to the *C* crystallographic axis of the original crystal. The extinction is parallel and the mean index is about 1.54 (higher than that of gypsum). The interference colors are low gray, and the character of the principal zone is positive.

(*b*) Soluble anhydrite also occurs as minute needles exceedingly intergrown, the structure being practically identical with that of $CaSO_4 \cdot \frac{1}{2}H_2O$. These crystals, however, possess an inclined extinction and a mean index of about 1.55. The double refraction is low, low-order gray and white being the interference colors noted.

Insoluble Anhydrite.

16. *Insoluble Anhydrite*, when first formed, has the same structure as that of $CaSO_4 \cdot \frac{1}{2}H_2O$ and soluble anhydrite, namely minute prismatic crystallites irregularly intergrown, the boundaries of whose aggregates are those of the original gypsum crystals. Both the indices of refraction and the double refraction are higher than those of soluble anhydrite, the index of the fast ray being about 1.57. The extinction is parallel and the optical character is biaxial positive. In all determinable properties it seems to be identical with normal anhydrite, but it is extremely fine grained. Just below its dissociation point the small needle crystallites reconsolidate, and the resulting crystal is comparatively large, agreeing with soluble anhydrite in all its optical properties.

Lime.

17. *Lime* crystallizes in rounded isotropic grains of index equal to 1.82 and is thus easily distinguishable from all other constituents.

Calcium Hydroxide.

18. *Calcium hydroxide*, amorphous, occurs in isotropic grains with an index of 1.58. It is also recognized by White's calcium-phenolate test. Due to insufficient water during hydration, it may show a strained condition which manifests itself by very low gray interference colors.

V. PRECAUTIONS FOR PHYSICAL TESTS.

Precautions for Physical Tests.

19. Gypsum products are peculiar in that their properties are very greatly affected by the small amounts of impurities which may be introduced by careless laboratory manipulation. In order to obtain concordant results, it is therefore absolutely essential to observe the following precautions:

(*a*) All apparatus shall be kept thoroughly clean. Especially shall all traces of set plaster be removed.

(*b*) Distilled water, free from chlorides and sulfates, shall be used throughout.

(*c*) Standard Ottawa sand shall be used throughout. This shall be prepared for use by washing it once with 1:4 HCl and four times with distilled water, and then drying it.

(*d*) For all physical tests, except time of set, sufficient retarder shall be added to the sample so that initial set will not occur within an hour. It is recommended that 0.1 per cent of a recognized commercial retarder be used for this purpose.

VI. NORMAL CONSISTENCY.

Normal Consistency.

20. In order that the results of testing samples of different plaster shall be directly comparable, it is necessary that all plasters be first brought to the same consistency, by the addition of the proper amount of water. An accurate method for determining normal consistency is the most important step in the standardizing of physical methods of testing cementing materials.

Apparatus.

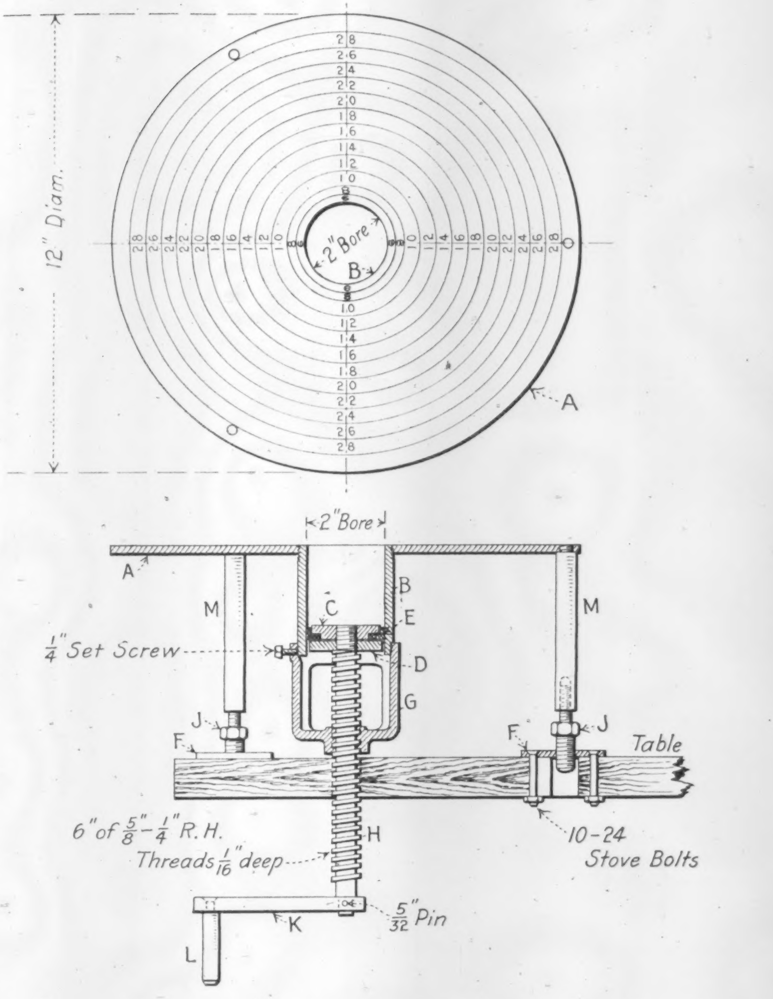
21. For a description of the apparatus to be used for measuring normal consistency, reference is made to the accompanying illustration (Fig. 1) of the Southard viscosimeter which has been used with satisfactory results.

The apparatus consists of a brass cylinder of 2-in. bore with a circular disk flange flush with its upper end. The screw actuating the piston is $\frac{5}{8}$ in. in outside diameter, $\frac{1}{4}$-in. pitch, right-hand square threads $\frac{1}{16}$ in. deep. The top of the brass disk flange is etched with concentric circles which vary in diameter from 6 cm. up to 28 cm. by increments of 2 cm.

When in position for use the brass flange is to be maintained in a true horizontal position.

Method.

22. To prepare this viscosimeter for use see that the piston,


12" Diam.
2" Bore
B
A
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
2" Bore
A
M
B
C
E
M
1/4" Set Screw
D
G
J
J
F
F
Table
6" of 5/8"-1/4" R.H.
Threads 1/16" deep
H
10-24
Stove Bolts
5/32" Pin
K
L

A; $\frac{3}{16}$" Hard Brass Plate Scale Disk.
B; 2" Ex. H. Seamless Brass Tube Cylinder.
C; Brass Piston Top.
D; " " Bottom.
E; Leather " Packing.
F; $\frac{3}{16}$" x 1" Flat Bar Steel Support Plate.
G; Brass Cage (Open on two Sides).
H; $\frac{5}{8}$" Hard Brass Piston Screw.
J; $\frac{1}{2}$" Hex. Brass Support Stud.
K; $\frac{3}{8}$" x $\frac{3}{4}$" C. R. S. Screw Lever.
L; $\frac{3}{8}$" Diam. C.R.S. Lever Handle.
M; $\frac{1}{2}$" Diam. C.R.S. Support Rod.

FIG. 1.—Southard Viscosimeter.

cylinder walls and top of plate are clean. Then by turning the crank, bring the top of the piston exactly flush with the top of the plate. Then by reverse cranking make ten complete turns, which will lower the piston to a point $2\frac{1}{2}$ in. below the top of the place. Next proceed to prepare the sample of dry calcined gypsum, adding to it and mixing with it thoroughly in the dry state, 0.1 per cent of retarder. Then make a mixture of at least 300 g. total of this retarded calcined gypsum and water. Add the retarded calcined gypsum to the water, allowing it to soak two minutes. Then stir vigorously to an even fluidity for one minute. Then immediately pour this mixture into the well in the center of the plate of the viscosimeter, filling the well just flush with the top of the plate. Then immediately turn the crank at the bottom of the viscosimeter ten turns at the rate of one turn per second. The upward motion of the piston will cause the mixture to overflow into a circular patty, it being understood that the top face of the circular disk of the instrument is to be adjusted and maintained in a true horizontal plane. Next take the average of the quadrant readings on the concentric lines on top of the plate.

A mixture is of normal consistency if with this operation it gives a circular patty averaging 9.7 cm. in diameter. The normal consistency shall be expressed as the number of cubic centimeters of water required to be added to 100 g. of the plaster under test in order to make the mixture of normal consistency.[1]

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[1] The following is recommended as a field method for the determination of normal consistency which will give fairly accurate results:

The apparatus shall consist of a piece of brass tubing 2 in. in inside diameter and 4 in. long, and a piece of plate glass about 8 in. square. The brass tubing shall be cut off true and square at the ends, and to the exact length. Thoroughly wet the cylinder and glass plate by immersion in clean water. Set the cylinder on end on top, and in the center of, the glass plate.

Prepare a dry sample of calcined gypsum by adding to it and mixing thoroughly, in a dry state, 0.1 per cent of retarder by weight. Next make a mixture of this retarded calcined gypsum and water of sufficient quantity to slightly more than fill the cylinder. The mixture shall be made by adding the retarded calcined gypsum to the water, allowing it to soak for two minutes. Now stir vigorously to an even fluidity for one minute and at once pour this mixture into the cylinder so as to completely fill it level with the top.

Immediately raise the cylinder from the glass with a quick, straight and upward motion so as to withdraw it from the stucco mass within. This act will allow the stucco and water mixture to leave the cylinder, assuming a cone-shaped circular patty upon the glass plate.

The normal consistency is a mixture which will give a circular patty averaging 9.7 cm. in diameter, and shall be expressed as the number of cubic centimeters of water required to be added to 100 g. of the plaster under test in order to make the mixture of normal consistency.

VII. DETERMINATION OF WATER-CARRYING CAPACITY.

Water-Carrying Capacity.

23. The water-carrying capacity of a plaster is the quantity of water required to bring it to a certain definite consistency as determined by the method described in Section 22.

VIII. DETERMINATION OF DRY BULK.

Dry Bulk.

24. The method of determining dry bulk shall consist of placing a 10-mesh screen above a 20-mesh screen, holding the two screens together at a height of 12 in. above a straight-sided receptacle of known volume, and of about 400 cc. content. Place the material under test on top of the 10-mesh screen and pass it through the 10 and 20-mesh screens, filling the receptacle under the 12-in. head, then striking off and obtaining a net weight of the contents in grams. The dry bulk is the average of five tests according to this method.

IX. DETERMINATION OF WET BULK.

Wet Bulk.

25. Wet bulk is the volume in cubic centimeters occupied by a mixture of 100 g. of plaster with as much water as it will take up when added to 100 cc. of water and permitted to settle for 2 minutes.

NOTE.—The method for determining wet bulk will be developed later by the Committee.

X. DETERMINATION OF TIME OF SETTING.

Time of Setting.

26. The time of setting of a plaster is the interval between the time when the plaster is added to the water and the time when the mixture is no longer workable.

NOTE.—Methods for determining the time of set are to receive the further consideration of the Committee. The relative merits of the "Penetration" and "Temperature rise" methods for initial and final set will be considered.

XI. DETERMINATION OF TENSILE STRENGTH.

Tensile Strength.

27. In a suitable vessel, place five times the quantity of water designated in Section 23. To this add 500 g. of the dried sample (Section 1). Let soak for 2 minutes. Mix vigorously with a trowel for one minute. Cast into a five-gang briquette

mold, of the shape and size used for testing Portland cement.[1] Do not cast each briquette successively, but move the containing vessel back and forth over the mold, while pouring continuously. Work the briquette slightly with the point of the trowel to remove air bubbles, and level off the briquettes. One hour later, remove the briquettes from the molds and place them in a damp closet. Twenty-four hours later remove them from the damp closet and place them in an air-tight drying closet in which is maintained a supply of calcium chloride sufficient to keep the humidity below 10 per cent. At the end of 7 days test the briquette in a standard form of machine for measuring tensile strength. If the strength of any one briquette does not vary more than 10 per cent from the average, the average shall be reported as the tensile strength of the material.

XII. DETERMINATION OF COMPRESSIVE STRENGTH.

28. Specifications to be supplied by the Committee when the information is available.

XIII. DETERMINATION OF SAND-CARRYING CAPACITY OF CALCINED GYPSUM.

29. It is the sense of the Committee that sand-carrying capacity cannot be defined by tensile strength. A method of measuring sand-carrying capacity should be based upon the working quality of the plaster when mixed with varying amounts of sand. The methods adopted should be independent of the nature of surface to which the sanded mixture is applied.

This problem may be solved by measuring the relative plasticities of sanded mixtures, and the Committee will have it under consideration during the coming year.

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[1] See Standard Specifications and Tests for Portland Cement (C 9), 1918 Book of A.S.T.M. Standards.

AMERICAN SOCIETY FOR TESTING MATERIALS
PHILADELPHIA, PA., U. S. A.
AFFILIATED WITH THE
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE DEFINITIONS
FOR
CLAY REFRACTORIES.[1]

Serial Designation: C 27 – 19 T.

These definitions are issued under the fixed designation C 27; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

1. The following definitions relating to the resistance to heat and the constancy of volume of clay refractories are recommended for the purpose of classification.

Method of Determining Softening Point.

2. The softening point referred to in the following definitions shall be determined in accordance with the Tentative Test for Determination of Softening Point of Fire-Clay Brick (Serial Designation: C 24 – 19 T)[2] of the American Society for Testing Materials.

Test for Linear Contraction or Expansion.

3. The test for linear contraction or expansion referred to in the following definitions shall be conducted in accordance with the Tentative Test for Determination of Porosity and Permanent Volume Changes in Refractory Materials (Serial Designation: C 20 – 18 T)[3] of the American Society for Testing Materials.

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[1] Criticisms of these Tentative Definitions are solicited and should be directed, preferably before January 1, 1920, to Mr. A. V. Bleininger, Chairman of Committee C-8 on Refractories, Bureau of Standards, Pittsburgh, Pa.

[2] See p. 594.

[3] See p. 590.

I. HIGH HEAT DUTY BRICK.

(*A*) *Clay Fire Brick.*

(Silica content less than 70 per cent.)

Softening Point.

4. The softening point of clay fire brick for high heat duty shall not be lower than that of standard cone No. 31 (about 1685° C., or 3065° F.).

Linear Contraction or Expansion.

5. When duplicate samples of clay fire brick for high heat duty are heated uniformly in a suitable furnace to a temperature of 1400° C. (2552° F.), maintained at this temperature for 5 hours, and cooled, they shall not show a contraction of more than 1.5 per cent of the original length nor an expansion of more than 1 per cent.

Option.

6. When a brick of this type softens at a temperature not below the softening point of standard cone No. 29 (about 1650° C., or 3002° F.) it may be tested according to classification (*B*) for silicious clay fire brick without losing in standing it if passes the tests.

(*B*) *Silicious Clay Fire Brick.*

(Silica content 70 per cent or over.)

Softening Point.

7. The softening point of silicious clay fire brick for high heat duty shall not be lower than that of standard cone No. 28 (about 1635° C., or 2975° F.).

Load Test.

8. All silicious clay fire brick for high heat duty shall be subjected to a load test in accordance with the requirements of the Tentative Test for Refractory Materials under Load at High Temperatures (Serial Designation: C 16–18 T)[1] of the American Society for Testing Materials. The pressure to be applied upon the brick (placed on end) shall be 25 lb. per sq. in. and the maximum furnace temperature 1350° C. (2462° F.). The brick shall not show a contraction of more than 4 per cent of the original length, nor an expansion of more than 1 per cent.

Linear Contraction or Expansion.

9. When duplicate samples of silicious clay fire brick for high heat duty are heated uniformly in a suitable furnace to a temperature of 1400° C. (2552° F.), maintained at this temperature for 5 hours, and cooled, they shall not show a contraction

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[1] See p. 581.

of more than 1.5 per cent of the original length nor an expansion of more than 1 per cent.

II. INTERMEDIATE HEAT DUTY BRICK.

Softening Point.

10. The softening point of brick for intermediate heat duty shall not be lower than that of standard cone No. 28 (about 1635° C., or 2975° F.).

Linear Contraction or Expansion.

11. When duplicate samples of brick for intermediate heat duty are heated uniformly in a suitable furnace to a temperature of 1350° C. (2462° F.), maintained at this temperature for 5 hours, and cooled, they shall not show a contraction of more than 1.5 per cent of the original length nor an expansion of more than 1 per cent.

III. MODERATE HEAT DUTY BRICK.

Softening Point.

12. The softening point of brick for moderate heat duty shall not be lower than that of standard cone No. 26 (about 1600° C., or 2912° F.).

Linear Contraction or Expansion.

13. When duplicate samples of brick for moderate heat duty are heated uniformly in a suitable furnace to a temperature of 1290° C. (2354° F.), maintained at this temperature for 5 hours, and cooled, they shall not show a contraction of more than 1.5 per cent of the original length nor an expansion of more than 1 per cent.

IV. LOW HEAT DUTY BRICK.

Softening Point.

14. The softening point of brick for low heat duty shall not be lower than that of standard cone No. 19 (about 1510° C., or 2750° F.).

AMERICAN SOCIETY FOR TESTING MATERIALS
PHILADELPHIA, PA., U. S. A.
AFFILIATED WITH THE
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE DEFINITIONS
OF
TERMS RELATING TO THE GYPSUM INDUSTRY.[1]

Serial Designation: C 11 - 16 T.

These definitions are issued under the fixed designation C 11; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916.

SYNOPSIS.

These definitions are divided into fifteen parts, under the following titles:

I. GYPSUM: ITS FORMS, FUNCTIONS AND PRODUCTS.

Giving the various forms in which gypsum is used, its functions in the various classes of products, and a list of these products classified according to these functions.

II. CEMENTITIOUS BASE PRODUCTS.

A development of the products classified according to the first function given under Part I.

III-VII.

A skeleton outline of the development of products classified according to the remaining functions given under Part I.

VIII. CLASSES, TYPES AND FORMS OF CEMENTITIOUS BASE PRODUCTS.

A development of the classes, types and forms of the products given in

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[1] Criticisms of these Tentative Definitions are solicited and should be directed, preferably before January 1, 1919, to Mr. V. G. Marani, Secretary of Committee C-11 on Gypsum, 111 W. Monroe St., Chicago, Ill.

Part II. The plan is to give the definition of each product as it is listed, it being the intention that this arrangement will show the reason for the adoption of certain terms, and for the avoidance of other terms.

IX–XIII.

To be a development, similar to Part VIII, of the classes, types and forms of the products given in Parts III–VII.

XIV. GLOSSARY.

Contains a list of the ingredients used in gypsum products with their definitions, and a list of terms the use of which should be avoided if possible.

XV. APPENDIX.

Contains a discussion of the reasons for the adoption or avoidance of all of the foregoing terms.

I. GYPSUM: ITS FORMS, FUNCTIONS AND PRODUCTS.

(*A*) FORMS.

Forms.

1. Gypsum is used in the arts in two forms:
   (*a*) Uncalcined.
      (1) Mass.
      (2) Crushed.
      (3) Ground.
   (*b*) Calcined.

(*B*) FUNCTIONS.

Functions.

2. Gypsum is used to function in several distinct ways:
   (*a*) As a cementitious base.
   (*b*) As a chemical.
   (*c*) As a pigment.
   (*d*) As a filler.
   (*e*) As a flux.
   (*f*) As a (other functions to follow).

(*C*) PRODUCTS.

Products.

3. Gypsum is mixed with other materials in the following classes of products:
   (*a*) As a cementitious base in
      (1) Coatings—applied in plastic form.
      (2) Bondings—applied in plastic form.

    (3) Structural products.
    (4) Cast products.
    (5) Pottery products.
(*b*) As a chemical in
    (1) Fertilizers.
    (2) Portland-cement manufacture.
    (3) Sulfuric-acid manufacture.
    (4) Brewing industry.
(*c*) As a pigment in
    (1) Paints, oil, or water.
(*d*) As a filler in
    (1) Paper.
    (2) Cloth.
(*e*) As a flux in
    (1) Brass melting.
(*f*) As a carrier for
    (1) Paris green.

II. CEMENTITIOUS BASE PRODUCTS.

(*A*) COATINGS.

Coatings. 4. Coatings applied in a plastic form are sub-divided as follows:

(*a*) *Plaster.*—A material used in a plastic state to form a hard covering for the ***interior*** surfaces, walls, ceilings, etc., of any building or structure. The word "plaster" is used without regard to the composition of the material, defining only its use and location of use as contrasted with the words "stucco" and "mortar."

For Gypsum Plaster, see Part VIII, Section 22 (*c*) *1*.

(*b*) *Stucco.*—A material used in a plastic state to form a hard covering for the *exterior* walls or other *exterior* surfaces of any building or structure. The word "stucco" is used without regard to the composition of the material, defining only its use and location of its use, as contrasted with the words "plaster" and "mortar."

For Gypsum Stucco, see Part VIII, Section 22 (*c*) *2*.

(*B*) BONDINGS.

Bondings.

5. Bondings applied in a plastic form are sub-divided as follows:

(*a*) *Mortar.*—A material used in a plastic state, becoming hard in place, to bond together such materials as brick, stone, tile, gypsum blocks, terra cotta, etc., in building walls, partitions, columns, foundations, piers, floors, and roof arches, etc. The word "mortar" is used without regard to the composition of the material, defining its use as a bonding material, as contrasted with the words "stucco" and "plaster."

For Gypsum Mortar, see Part VIII (*B*)—(Definition to follow.)

(*C*) STRUCTURAL PRODUCTS.

Structural Products.

6. Gypsum structural products are sub-divided as follows: (Definitions to follow.)

(*a*) *Gypsum Plaster Boards.*

(*b*) *Gypsum Blocks* are sub-divided as follows:
  (1) Floor tile.
  (2) Book tile.
  (3) Roof tile.
  (4) Partition blocks.
  (5) Furring tile.
  (6) Column covering.

(*c*) *Concrete* is sub-divided as follows:
  (1) Arches—floor and roof.

(*D*) CAST PRODUCTS.

Cast Products.

7. Gypsum cast products are sub-divided as follows: (Definitions to follow.)

(*E*) POTTERY PRODUCTS.

Pottery Products.

8. Gypsum pottery products are sub-divided as follows:

(Definitions to follow.)

III. CHEMICAL PRODUCTS.

(*A*) FERTILIZERS.

Fertilizers.

9. Gypsum fertilizers are sub-divided as follows:

(Definitions to follow.)

(*B*) PORTLAND-CEMENT MANUFACTURE.

Portland-Cement Manufacture.

10. The uses of gypsum in Portland-cement manufacture may be sub-divided as follows:

(Definitions to follow.)

(*C*) SULFURIC-ACID MANUFACTURE.

Sulfuric-Acid Manufacture.

11. The uses of gypsum in sulfuric-acid manufacture may be sub-divided as follows:

(Definitions to follow.)

(*D*) (Title to follow.)

12. The uses of gypsum in (another chemical process) may be sub-divided as follows:

(Definitions to follow.)

IV. PIGMENT PRODUCTS.

(*A*) COATINGS APPLIED WITH BRUSH.

Coatings Applied with Brush.

13. Liquid gypsum coatings applied with a brush are sub-divided as follows:

(Definitions to follow.)

(*B*) (Title to follow.)

14. (Another pigment product) are sub-divided as follows:

(Definitions to follow.)

V. FILLER PRODUCTS.

(*A*) PAPER FILLERS.

15. Gypsum paper fillers are sub-divided as follows: **Paper Fillers.**

(Definitions to follow.)

(*B*) CLOTH FILLERS.

16. Gypsum cloth fillers are sub-divided as follows: **Cloth Fillers.**

(Definitions to follow.)

(*C*) (Title to follow.)

17. Gypsum (other fillers) are sub-divided as follows:

(Definitions to follow.)

VI. FLUX PRODUCTS.

(*A*) FOUNDRY-CORE FLUXES.

18. Gypsum foundry-core fluxes are sub-divided as follows: **Foundry-Core Fluxes.**

(Definitions to follow.)

(*B*) (Title to follow.)

19. Gypsum (other fluxes) are sub-divided as follows:

(Definitions to follow.)

VII. (Other) PRODUCTS.

(*A*) (Title to follow.)

20. Gypsum (other products) are sub-divided as follows:

(Definitions to follow.)

(*B*) (Title to follow.)

21. Gypsum (other products) are sub-divided as follows:

(Definitions to follow.)

VIII. CLASSES, TYPES AND FORMS OF CEMENTITIOUS BASE PRODUCTS.

(*A*) COATINGS.

Classes of Coatings.

22. *Classes.*—Gypsum coatings applied in plastic form (plasters and stuccoes) are divided into several classes depending upon the predominating cementitious material, as follows:

(*a*) *Lump-Lime Plaster and Stucco.*

- *1. Lump-Lime Plaster.*—A plaster in which the predominating cementitious material is lime putty made by slaking quicklime at the job.
- *2. Lump-Lime Stucco.*—A stucco in which the predominating cementitious material is lime putty made by slaking quicklime at the job.

(*b*) *Hydrated-Lime Plaster and Stucco.*

- *1. Hydrated-Lime Plaster.*—A plaster in which the predominating cementitious material is hydrated lime. It may be either "job-mixed plaster" or "prepared plaster." (See Section 23.)
- *2. Hydrated-Lime Stucco.*—A stucco in which the predominating cementitious material is hydrated lime. It may be either "job-mixed stucco" or "prepared stucco." (See Section 23 (*a*)*2*, or (*b*)*2*.)

( ) *Gypsum Plaster and Stucco.*

- *1. Gypsum Plaster.*—A plaster in which the predominating cementitious material is calcined gypsum.

  (Frequently called "cement plaster," "hard wall plaster," "patent plaster," "calcined plaster," "rock-wall plaster," "stucco wall plaster," etc. The use of these terms should be avoided.)

- *2. Gypsum Stucco.*—A stucco in which the predominating cementitious material is calcined gypsum.

(*d*) *Keene's-Cement Plaster and Stucco.*

- *1. Keene's-Cement Plaster.*—A plaster in which the predominating cementitious material is Keene's cement.
- *2. Keene's-Cement Stucco.*—A stucco in which the predominating cementitious material is Keene's cement.

(e) *Portland-Cement Plaster and Stucco.*

1. *Portland-Cement Plaster.*—A plaster in which the predominating cementitious material is Portland cement.
2. *Portland-Cement Stucco.*—A stucco in which the predominating cementitious material is Portland cement.

(f) *Natural-Cement Plaster and Stucco.*

1. *Natural-Cement Plaster.*—A plaster in which the predominating cementitious material is natural cement.
2. *Natural-Cement Stucco.*—A stucco in which the predominating cementitious material is natural cement.

Forms of Coatings.

23. *Forms.*—Plasters and stuccoes are divided into several forms depending upon the amount of mixing done at the mill of the producer as follows:

(a) *Job-Mixed Plaster and Stucco.*

1. *Job-Mixed Plaster.*—A plaster in which all the ingredients are mixed at the job.
2. *Job-Mixed Stucco.*—A stucco in which all the ingredients are mixed at the job.

(b) *Prepared Plaster and Stucco.*

1. *Prepared Plaster.*—A plastering material mixed at the mill by the producer with all the constituent parts in their proper proportion, with the exception of the aggregate which may or may not be incorporated with the mixture at the mill.

   Prepared plasters are sub-divided into "ready-mixed plasters" and "neat plasters." See definition of these plasters.
2. *Prepared Stucco.*—A stucco material mixed at the mill by the producer with all the constituent parts in their proper proportion, with the exception of the aggregate which may or may not be incorporated with the mixture at the mill.

   Prepared stuccoes are sub-divided into "ready mixed stucco" and "neat stuccoes." See definitions of these stuccoes.

3. Ready-Mixed Plaster.—A "prepared plaster" requiring only the addition of water to make it ready for use.

This term distinguishes "ready-mixed plaster" from "neat plaster."

4. Ready-Mixed Stucco.—A "prepared stucco" requiring only the addition of water to make it ready for use.

This term distinguishes "ready-mixed stucco" from "neat stucco."

5. Neat Plaster.—A "prepared plaster" requiring the addition of both the aggregate and water to make it ready for use.

This term distinguishes "neat plaster" from "ready-mixed plaster."

6. Neat Stucco.—A "prepared stucco" requiring the addition of both the aggregate and water to make it ready for use.

This term distinguishes "neat stucco" from "ready-mixed stucco."

Types of Coatings. 24. *Types.*—Plasters and stuccoes are divided into several types depending upon the following conditions:

(*a*) *Material Used as an Aggregate.*

1. Sand Plaster and Sand Stucco.

Sand Plaster.—A plaster in which sand is used as the aggregate. This expression is used without regard to either the cementitious material employed, or the place of mixing the ingredients.

This term distinguishes "sand plaster" from "pulp plaster."

Sand Stucco.—A stucco in which sand is used as the aggregate. This expression is used without regard to either the cementitious material employed, or the place of mixing the ingredients.

This term distinguishes "sand stucco" from "pulp stucco."

2. Pulp Plaster and Pulp Stucco.

Pulp Plaster.—A plaster in which pulp is used as the aggregate. This expression is used without regard to either the cementitious material employed or the place of mixing the ingredients.

This expression distinguishes "pulp plaster" from "sand plaster."

Pulp Stucco.—A stucco in which pulp is used as the aggregate. This expression is used without regard to either the cementitious material employed or the place of mixing the ingredients.

This expression distinguishes "pulp stucco" from "sand stucco."

3. *Fiber Plaster and Fiber Stucco.*

Fiber Plaster.—A plaster in which fiber is used as the aggregate. This expression is used without regard to either the cementitious material employed or the place of mixing the ingredients.

Fiber Stucco.—A stucco in which fiber is used as the aggregate. This expression is used without regard to either the cementitious material employed or the place of mixing the ingredients.

(*b*) *Number of Coats.*

1. *Two-Coat Work.* (Definition to follow.)
2. *Three-Coat Work.* (Definition to follow.)

First or Scratch Coat.—The first coat of plaster or stucco. It is applied directly to the lath or masonry surfaces to be covered, and is scratched before thoroughly dry to provide a better bond for the next coat.

Second or Browning Coat.—The second coat of plaster or stucco. Generally used only in three-coat work, but does sometimes mean the finishing coat in two-coat work.

(*c*) *Method of Application.*

1. *Dry Scratch Work.* (Definition to follow.)
2. *Doubled-up Work.* (Definition to follow.)
3. *Drawn Work.* (Definition to follow.)

(*d*) *Finish.*—The finish given to a plastered or stuccoed surface is sub-divided as follows:

Finish or White Coat.—The last coat of plaster or stucco. In three-coat work it is applied to the second coat, and in two-coat work it is applied to the first coat, and then sometimes known as the second coat.

1. *White Troweled or Smooth Finish.* (Definition to follow.)
2. *Sand-Float or Rough Finish.* (Definition to follow.)
3. *Pebble Dash Finish.* (Definition to follow.)
4. *Stippled Finish.* (Definition to follow.)

(*B*) BONDINGS.

Development of Part II (*B*), Section 5. Definitions to follow.

(*C*) STRUCTURAL PRODUCTS.

Development of Part II (*C*), Section 6. Definitions to follow.

(*D*) CAST PRODUCTS.

Development of Part II (*D*), Section 7. Definitions to follow.

(*E*) POTTERY PRODUCTS.

Development of Part II (*E*), Section 8. Definitions to follow.

IX. CLASSES, TYPES AND FORMS OF CHEMICAL PRODUCTS.

Development of Part III, Sections 9–12. Definitions to follow.

X. CLASSES, TYPES AND FORMS OF PIGMENT PRODUCTS.

Development of Part IV, Sections 13–14. Definitions to follow.

XI. CLASSES, TYPES AND FORMS OF FILLER PRODUCTS.

Development of Part V, Sections 15–17. Definitions to follow.

XII. CLASSES, TYPES AND FORMS OF FLUX PRODUCTS.

Development of Part VI, Sections 18–19. Definitions to follow.

XIII. CLASSES, TYPES AND FORMS OF (Other) PRODUCTS.

Development of Part VII, Sections 20–21. Definitions to follow.

XIV. GLOSSARY.

(*A*) DEFINITIONS OF INGREDIENTS OF GYPSUM PRODUCTS.

1. *Gypsum.*—Gypsum is a hydrous calcium sulfate, formula $CaSO_4.2H_2O$, which may contain varying percentages of silica, alumina, iron oxide, and carbonates of calcium and magnesium.

   Limitations as to percentages of impurities should be established.

2. *Uncalcined Gypsum.*—A synonym for gypsum.

   Generally used to mean the raw material as taken from the mine or quarry for commercial use.

3. *Mass Gypsum.*—(Definition to follow.)
4. *Crushed Gypsum.*—A form of uncalcined gypsum. The size (state size limitations), distinguishing it from "ground gypsum."
5. *Ground Gypsum.*—A form of uncalcined gypsum. The size (state size limitations), distinguishing it from "crushed gypsum."
6. *Calcined Gypsum.*—A product resulting from the partial or complete calcination of gypsum. A cementitious material often used in stuccoes, plasters, mortars, concretes, etc., as the active setting material.

   Chemically pure calcined gypsum has the formula $CaSO_4.H_2O$. The commercial material has the same impurities as gypsum; silica, alumina, iron oxide, and carbonates of calcium and magnesium. Limitations as to percentage of impurities should be established. Frequently called "Plaster of Paris," the use of which should be avoided. (See Part XIV, Glossary, Section 29.)

7. *Cement.*—A material or a mixture of materials having cementitious properties (as hydrated lime, Portland cement, calcined gypsum, natural cement, glue, asphalt, Keene's cement, etc.). The word "cement" is used without regard to the composition of the material, and does not define its use or location of use as do the words "stucco," "plaster" and "mortar."

8. *Concrete.*—A mixture of one or more cementitious materials (as Portland cement, hydrated lime, calcined gypsum, natural cement, etc.), with an aggregate of sand, broken stone, cinders, asbestos fiber, etc., which becomes a solid mass when the cementitious materials have hardened.

9. *Portland Cement.*—The product obtained by finely pulverizing clinker produced by calcining to incipient fusion an intimate and properly proportioned mixture of argillaceous and calcareous materials, with no additions subsequent to calcination excepting water and calcined or uncalcined gypsum.

Definition taken from Standard Specifications and Tests for Portland Cement (Serial Designation: C 9) of the American Society for Testing Materials.[1]

10. *Natural Cement.*—The finely pulverized product resulting from the calcination of an argillaceous limestone at a temperature only sufficient to drive off the caronbic acid gas.

Definition taken from Standard Specifications for Cement (Serial Designation: C 10) of the American Society for Testing Materials.[1]

11. *Keene's Cement.*—(Definition to follow.)

12. *Quicklime.*—A material the major part of which is calcium oxide or calcium and magnesium oxide, which will slake on the addition of water.

Definition taken from Standard Specifications for Quicklime (Serial Designation: C 5) of the American Society for Testing Materials,[1] where it is divided into two forms, "lump" and "pulverized." See definitions of "lump lime" and "pulverized lime."

Also known as "lime," "lump lime," "burned lime," "calcinde lime," the use of which terms should be avoided.

13. *Lump Lime.*—A form of quicklime. The size taken from the kiln without crushing or grinding, distinguishing it from "pulverized lime."

Definition taken from Standard Specifications for Quicklime (Serial Designation: C 5) of the American Society for Testing Materials.[1] The form of quicklime generally slaked at the job tc make "lime putty."

14. *Pulverized Lime.*—A form of quicklime; "lump lime" reduced in size to pass a $\frac{1}{4}$-in. screen, distinguishing it from "lump lime."

Definition taken from Standard Specifications for Quicklime

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[1] See 1918 Book of A.S.T.M. Standards.

(Serial Designation: C 5) of the American Society for Testing Materials.[1] This form of quicklime is seldom slaked at the job to produce "lime putty."

15. *Hydrated Lime.*—A cementitious material often used in stucco, plaster, mortar, etc., as an active setting agent. Always prepared at the mill of the producer and never made at the job from quicklime.

The definition given in the Standard Specifications for Hydrated Lime (Serial Designation: C 6) of the American Society for Testing Materials[1] is as follows: "A dry flocculent powder resulting from the hydration of quicklime." Analysis required by these specifications permits only the amount of water necessary to satisfy chemical hydration. This makes production of hydrated lime impossible at the job.

16. *Lime Putty.*—The predominating cementitious material in lime plaster, lime stucco and lime mortar. Made by slaking "quicklime" with an excess of water, or by adding water to "hydrated lime." A white, cream-like, smooth plastic paste.

Also called "slaked lime," the use of which term should be avoided.

17. *Lime Paste.*—A synonym of "lime putty."
18. *Aggregate.*—The inert materials used as a filler in stucco, plaster, mortar, concrete mixtures, without regard to their function as a binding material.
19. *Fine Aggregate.*—(Definition to follow.)
20. *Filler.*—A synonym for "aggregate."
21. *Sand.*—(Definition to follow.)
22. *Pulp.*—A binder used in stucco and plaster. Made by grinding, crushing or shredding wood in a manner similar to that in preparing wood pulp in paper manufacture. One of the general classes of fiber binders.
23. *Binder.*—A material used in stucco and plaster to increase the tensile strength, intended to prevent cracking and crumbling.
24. *Fiber.*—A general class of material used as binders in stucco and plaster. May be of wood, asbestos, hemp, etc.
25. *Hair.*—A binder used in stucco and plaster. Obtained from goats, cattle or other animals. One of the general class of fiber binders.

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[1] See 1918 Book of A.S.T.M. Standards.

26. *Asbestos.*—(Definition to follow.)

27. *Retarders.*—Any material used in stucco, plaster, mortar, concrete, etc., to reduce the rapidity with which the cementitious materials set.

28. *Accelerators.*—Any material used in stucco, plaster, mortar, concrete, etc., to increase the rapidity with which the cementitious materials set.

(*B*) TERMS, THE USE OF WHICH SHOULD BE AVOIDED IF POSSIBLE.

29. *Plaster-of-Paris.*—This term uses "plaster" in a sense not in agreement with the definition. Also, this material is wrongly considered to be plaster, resulting in misunderstandings. "Calcined gypsum" is the term that should be used. (See Part XIV, Glossary, Section 6.)

30. *Cement Plaster.*—The term lacks definiteness, as it has been used to mean both "gypsum plaster" and "Portland-cement plaster."

31. *Hard Wall Plaster.*—See Part XV, Appendix, Section 20.

32. *Rock Wall Plaster.*—See Part XV, Appendix, Section 20.

33. *Patent Plaster.*—See Part XV, Appendix, Section 20.

34. *Calcined Plaster.*—See Part XV, Appendix, Section 20.

35. *Stucco Plaster.*—See Part XV, Appendix, Section 20.

36. *Wall Plaster.*—See Part XV, Appendix, Section 20.

37. *Stucco Wall Plaster.*—See Part XV, Appendix, Section 20.

38. *Ceiling Plaster.*—See Part XV, Appendix, Section 20.

39. *Dry Mortar.*

40. *Bag Mortar.*

41. *Plaster Mortar.*

42. *Stucco Mortar.*

43. *Lime.*—It has been misused to mean any cementitious lime material without regard to its chemical or physical nature, and now lacks specific meaning. Chemically pure lime (CaO) is seldom used in the arts. See definition of "quicklime."

44. *Burned Lime.*—See definition of "quicklime," Part XIV, Glossary, Section 12.

45. *Calcined Lime.*—See definition of "quicklime," Part XIV, Glossary, Section 12.

46. *Slaked Lime.*—See definition of "lime putty" or "lime paste," Part XIV, Glossary, Sections 16 or 17.

47. *Building Lime.*—See definition of "quicklime," "lump lime," "pulverized lime," "hydrated lime," Part XIV, Glossary, Sections 12-15.

48. *Land Plaster.*

APPENDIX.

XV. DEVELOPMENT OF DEFINITIONS.

(*A*) STUCCO.

1. The word "stucco" is derived from the old High German word "stuchhi" meaning "a crust" or "piece." **Stucco.**

2. Webster's Unabridged Dictionary defines the "stucco" as "plaster of any kind used as a coating for walls; especially a fine plaster, composed of lime or gypsum, sand and pounded marble, used for internal decorations and fine work." From this it appears that "stucco" may mean a coating for either exterior or interior walls, with particular reference to interior ornamental work as moldings, cornices, etc.

3. Manufacturers have used the word stucco to mean different materials without regard to the location of the surface to which it is applied. The following shows how "stucco" has been used by various manufacturers.

(*a*) Atlas Wall Plaster Co., Louisville, Ky., produce "Atlas Stucco Finish" for interior finish only, which is a calcined gypsum product.

(*b*) Michigan Gypsum Co., Grand Rapids, Mich., produce "N. P. Brand Stucco" for interior finish only, which is a calcined gypsum product.

(*c*) Plymouth Gypsum Co., Fort Dodge, Iowa, produce "Plymouth Rock Stucco," use not given, but probably for *exterior* work; which is a calcined gypsum product.

(*d*) The Associated Metal Lath Manufacturers have defined "stucco" as referring solely to a covering of an exterior wall without regard to the composition of the material.

(*e*) Monument Plaster Co., Harrison, N. J., produce "Oriental Stucco," a material for exterior finish only. This is a lime product.

(*f*) The Association of American Portland Cement Manufacturers have prepared Bulletin No. 22 on Portland-Cement Stucco. In this Bulletin "stucco" is used to mean a covering of an exterior wall only.

4. An examination of other literature in which the word "stucco" is used shows the following:

(*a*) Mr. Edwin C. Eckel, C.E., in his book on "Cements, Limes and Plasters" considers "stucco" as a synonym for Plaster of Paris without definition as to its use in exterior or interior work.

(*b*) Many books describing exterior treatments for buildings by applying coatings of cementitious materials, use the word "stucco" in describing the materials.

(*c*) The paint manufacturers that produce materials for coloring, dampproofing and weatherproofing stucco use the word "stucco" to mean the material used to coat an exterior wall.

(*d*) Among architects, building contractors, and building owners, the word "stucco" has grown to mean an exterior wall covering or coating.

5. Consequently, it is advisable to discontinue the use of the word "stucco" to describe a covering material for an interior surface; since, where the greatest study of the materials for exterior surface covering has been made, "stucco" has been used to differentiate this use of material from all others.

(*B*) PLASTER.

Plaster. 6. The word "plaster" is derived from the Greek and Latin words meaning "to daub on" or "to stuff in."

7. Webster's Unabridged Dictionary defines "plaster" as "a composition of lime, water and sand with or without hair as a bond, for coating walls, ceilings and partitions of houses;" also as "calcined gypsum or plaster of Paris, especially when ground, as used for making ornaments, figures, moldings, etc."

8. For many years, plasters have been divided into two classes, interior and exterior plasters, depending upon the location or exposure of the surface to which the material is applied. Exterior plaster is better defined as "stucco" and should be so called. As a result, the above distinction is not necessary and by elimination, "plaster" means but one thing, namely: a coating for interior surface not exposed to weather.

9. Objection to this limitation in the definition of plaster will perhaps be made by those who use the term "exterior plaster" rather than stucco and the few using "stucco" to mean a special form of material for interior work.

10. It will be noted that the definition of "plaster" proposed in Part II, Section 4 (*a*), does not include uses of the material not given in either the root of the word or in its dictionary definition. The proposed definition merely limits the meaning of the word in order to make it a foundation on which can be built a collection of terms that will accurately describe the many various materials and mixtures used in plastering.

11. This restricted use of the word "plaster" will prevent the present confusion between plasters and the materials used in making plaster, and make clear at once the designed use of the material. Evidence of this confusion is found in the expression "Plaster of Paris," which to many has meant "plaster." The preceding definitions have shown that this material is not plaster, but rather is "calcined gypsum," which it should be called. Other confusing expressions are "stucco wall plaster," and "stucco plaster," which have been used in the past without regard to the location of the use of the material, and mean either interior or exterior wall covering material depending only upon the connection in which they are used or the nature of the product produced by the manufacturer marketing the materials. All these and similar misunderstandings are obviated by using the suggested definitions for "plaster" and "stucco."

(*C*) MORTAR.

12. The word "mortar" is derived from the Latin word "mortarium," meaning a vessel in which substances are pounded or rubbed, and later the pounded or rubbed substances. **Mortar.**

13. Webster's Unabridged Dictionary defines the word as "a building material made by mixing lime, cement or plaster of Paris with sand, water and sometimes other materials; used in masonry for joining stones, bricks, etc., also for plastering and in other ways." From this it appears that "mortar" means the same as that given in preceding paragraphs for stucco, plaster, and mortar.

14. The use of the word "mortar" as given in Part II, Section 5 (*a*), adds no new meaning, but restricts it to a particular use, rendering unnecessary such expressions as "stucco mortar,"

"plaster mortar," etc. It will also remove the confusion resulting from using the same expression to define materials used in making stuccoes, plasters and mortars.

(*D*) PLASTERS AND PLASTERING MATERIALS.

Plasters and Plastering Materials.

15. A careful distinction should be made between plaster and the materials used to make plaster. For instance, hydrated lime may or may not be mixed with sand or other aggregates and a binder to make plaster. In this case, if the plaster is used for scratch or brown coat work, no one individual material is plaster, but the completed mixture is plaster. It is obvious that the aggregate or fiber, even when water is added, does not constitute plaster; consequently the hydrated lime in this case is not justly considered plaster, as it is a part of the mixture in the same manner that the aggregate and binder are parts of the mixture. However, in finishing coat work, if calcined gypsum is not added to gage the mixture, the hydrated lime is plaster.

16. The statements in Section 15 are not contradictory when the definition for "plaster" in Part II, Section 4 (*a*), is carefully considered. Also, this distinction will cause no confusion in practice, as hydrated lime, or even calcined gypsum, is seldom used alone in finishing coat work, the two materials being mixed together to make finishing coat plaster.

17. An examination of literature descriptive of this class of plaster shows a confusing variety of different expressions, all of which are used in naming the same materials used for the same purpose. Some of these terms and the producers using them are as follows:

Cement Plaster is used by:

Plaster Manufacturers' Assoc.
U. S. Gypsum Co.
Michigan Gypsum Co.
Overland Gypsum Co.
American Gypsum Co.
Southern Gypsum Co.
Atlas Wall Plaster Co.
Texas Cement Co.
Arden Plaster Co.
Crown Gypsum Co.
Plymouth Gypsum Co.
Manitoba Gypsum Co.
American Cement Plaster Co.
Rock Plaster Mfg. Co.
J. B. King and Co.
The Alabastine Co.
Acme Cement Plaster Co.
Wotherspoon Plaster Mills, Inc.

18. From this list, which is only representative, it is evident that in the central and western parts of this country "cement plaster" is very generally used to mean "gypsum plaster." Without doubt, many people must think that "gypsum or calcined gypsum" means the same as "cement." This understanding must cause much confusion, as there are a large number of people who consider cement to mean Portland, Rosendale, Keene's, etc., cement.

19. The suggested use of the terms "gypsum plaster" (Part VIII, Section 22 (*c*) *1*) and "cement" (Part XIV, Glossary, Section7) will prevent many misunderstandings.

20. *Hard Wall Plaster*, *Rock Wall Plaster*, *Patent Plaster*, *Calcined Plaster*, *Wall Plaster*, *Stucco Wall Plaster*, etc., are some of the expressions used to mean the material that has been defined as "gypsum plaster." These expressions have not been as generally used as "cement plaster," and of themselves may not have produced misunderstandings, since, with the exception of "stucco wall plaster," they have not been construed to mean other materials than "gypsum plaster." The expression "gypsum plaster" has an advantage over all these terms in that it denotes the particular cementitious material that is used in causing the plaster to harden.

AMERICAN SOCIETY FOR TESTING MATERIALS

PHILADELPHIA, PA., U. S. A.

AFFILIATED WITH THE

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS
FOR
FOOTS PERMISSIBLE IN PROPERLY CLARIFIED PURE RAW LINSEED OIL FROM NORTH AMERICAN SEED.[1]

Serial Designation: D 51 - 18 T.

These specifications are issued under the fixed designation D 51; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1918.

I. PERCENTAGE OF FOOTS.

Percentage of Foots.

1. The amount of foots in properly clarified pure raw linseed oil from North American seed, as determined by the test specified below, shall not exceed 2 per cent by volume.

II. METHOD OF DETERMINATION.

Reagents Required.

2. The following reagents are required:

(*a*) Acetone that will pass United States Pharmacopœia specifications.

(*b*) Acid $CaCl_2$ solution, made by saturating with $CaCl_2$ a mixture of 90 parts water and 10 parts concentrated HCl, sp. gr. 1.2, at room temperature.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. G. W. Thompson, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 129 York St., Brooklyn, N. Y.

3. With all materials at a temperature between 70 and 80° F., mix by shaking in a stoppered flask for exactly one minute, 25 cc. of the well-shaken sample of oil, 25 cc. of acetone and 10 cc. of the acid $CaCl_2$ solution. Transfer the mixture to a burrette where settling can take place for 24 hours. The temperature during this period should be between 70 and 80° F. **Operation.**

The volume of the strata lying between the clear calcium-chloride solution and the clear acetone and oil mixture is read in tenths of a cubic centimeter or a fraction thereof. This reading multiplied by four expresses the amount of foots present as percentage by volume of the oil taken.

AMERICAN SOCIETY FOR TESTING MATERIALS

PHILADELPHIA, PA., U. S. A.

AFFILIATED WITH THE

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS FOR MATERIALS FOR CEMENT GROUT FILLER FOR BRICK AND STONE BLOCK PAVEMENT.[1]

Serial Designation: D 57 – 19 T.

These specifications are issued under the fixed designation D 57; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

I. SAND FOR CEMENT GROUT FILLER.

Sand. 1. The sand shall consist of clean, hard, durable stone particles, preferably siliceous, free from lumps of clay and objectionable foreign matter.

Grading. 2. (*a*) The sand shall be well graded from coarse to fine and when tested by means of laboratory sieves shall meet the following requirements:

		Per Cent.
Total passing 10-mesh sieve		100
Total passing 20-mesh sieve	not less than	80
Total passing 200-mesh sieve	not more than	5

(*b*) This test shall be made in accordance with the Standard Method for Making a Mechanical Analysis of Sand or Other Fine Highway Material, except for Fine Aggregates Used in

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road Materials, 15 Maiden Lane, New York City.

Cement Concrete (Serial Designation: D 7) of the American Society for Testing Materials.[1]

Mortar Strength Test.

3. (*a*) When the sand is mixed with Portland cement passing the requirements of the Standard Specifications and Tests for Portland Cement (Serial Designation: C 9) of the American Society for Testing Materials,[1] in the proportion of 1 part of cement to 3 parts of sand, by weight, according to the standard method of making 1:3 mortar briquettes, the resulting mortar at the age of 7 and 28 days shall have a tensile strength of at least 75 per cent of that developed in the same time by mortar of the same consistency, made of 1 part of the same cement and 3 parts of Ottawa sand.

(*b*) Preliminary acceptance samples shall be subjected to both 7 and 28-day mortar tests, and acceptance based thereon. Samples tested during the progress of the work will be accepted on the basis of the 7-day test.

(*c*) The tests for mortar strength shall be made in accordance with the A.S.T.M. Standard Specifications and Tests for Portland Cement.

NOTE.—The Portland cement used in testing the proposed sand should preferably be that used or to be used in the work.

Inspection.

4. The sand shall be subject to inspection after delivery at the place of use, prior to and during the laying of the pavement.

Sampling.

5. The sand shall be sampled for testing at the source of supply, if required. Samples shall also be taken for testing from time to time, at the place of use prior to and during the laying of the pavement, whenever desired by the engineer.

II. PORTLAND CEMENT FOR CEMENT GROUT FILLER.

Cement.

6. Portland cement for use in cement grout filler shall conform to the requirements of the A.S.T.M. Standard Specifications and Tests for Portland Cement (Serial Designation: C 9).

III. WATER FOR CEMENT GROUT FILLER.

Water.

7. Clean water free from harmful amounts of oil, acid, alkali, organic or vegetable matter shall be used.

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[1] 1918 Book of A.S.T.M. Standards.

AMERICAN SOCIETY FOR TESTING MATERIALS

PHILADELPHIA, PA., U. S. A.

AFFILIATED WITH THE

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS FOR MATERIALS FOR CEMENT MORTAR BED FOR BRICK, STONE BLOCK AND WOOD BLOCK PAVEMENT.[1]

Serial Designation: D 58 – 19 T.

These specifications are issued under the fixed designation D 58; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

I. SAND FOR CEMENT MORTAR CUSHION.

Sand. 1. The sand shall consist of clean, hard, durable stone particles, preferably siliceous, free from lumps of clay and any objectionable foreign matter.

Grading. 2. (*a*) The sand shall be well graded from coarse to fine and when tested by means of a laboratory sieve shall meet the following requirements:

Total passing 10-mesh sieve.................... 100 per cent.

(*b*) This test shall be made in accordance with the Standard Method for Making a Mechanical Analysis of Sand or Other Fine Highway Material, except for Fine Aggregates Used in Cement Concrete (Serial Designation: D 7) of the American Society for Testing Materials.[2]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road Materials, 15 Maiden Lane, New York City.

[2] 1918 Book of A.S.T.M Standards.

Mortar Strength Test. 3. (*a*) When the sand is mixed with Portland cement passing the requirements of the Standard Specifications and Tests for Portland Cement (Serial Designation: C 9) of the American Society for Testing Materials,[1] in the proportion of 1 part cement to 3 parts of sand, by weight, according to the standard method of making 1:3 mortar briquettes, the resulting mortar at the age of 7 and 28 days shall have a tensile strength of at least 75 per cent of that developed in the same time by mortar of the same consistency, made of 1 part of the same cement and 3 parts of Ottawa sand.

(*b*) Preliminary acceptance samples shall be subjected to both 7 and 28-day mortar tests, and acceptance based thereon. Samples tested during the progress of the work will be accepted on the basis of the 7-day test.

(*c*) The tests for mortar strength shall be made in accordance with the A.S.T.M. Standard Specifications and Tests for Portland Cement.

NOTE.—The Portland cement used in testing the proposed sand should preferably be that used or to be used in the work.

Inspection. 4. The sand shall be subject to inspection after delivery at the place of use, prior to and during the laying of the pavement.

Sampling. 5. The sand shall be sampled for testing at the source of supply, if required. Samples shall also be taken for testing from time to time, at the place of use prior to and during the laying of the pavement, whenever desired by the engineer.

II. PORTLAND CEMENT FOR CEMENT MORTAR BED.

Cement. 6. Portland cement for use in the cement mortar cushion shall conform to the requirements of the A.S.T.M. Standard Specifications and Tests for Portland Cement (Serial Designation: C 9).

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[1] 1918 Book of A.S.T.M. Standards.

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TENTATIVE SPECIFICATIONS
FOR
BLOCK FOR GRANITE BLOCK PAVEMENT.[1]

Serial Designation: D 59 – 19 T.

These specifications are issued under the fixed designation D 59; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

General. 1. The blocks shall be of granite of medium-size grain, showing an even distribution of constituent minerals. They shall be of uniform quality and texture throughout, and free from seams or disintegrated materials.

I. PHYSICAL PROPERTIES AND TESTS.

Physical Properties. 2. The average of three tests on sample blocks shall conform to the following requirements as to physical properties:

FOR HEAVY TRAFFIC.

French coefficient of wear	not less than	11
Toughness	" " "	9

FOR MODERATELY HEAVY TRAFFIC.

French coefficient of wear	not less than	8
Toughness	" " "	7

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road Materials, 15 Maiden Lane, New York City.

Methods of Testing.

3. (*a*) The French coefficient of wear shall be determined in accordance with the Standard Test for Abrasion of Road Material (Serial Designation: D 2) of the American Society for Testing Materials.[1]

(*b*) The toughness shall be determined in accordance with the Standard Test for Toughness of Rock (Serial Designation: D 3) of the American Society for Testing Materials.[1]

II. DIMENSIONS.

Dimensions.

4. The blocks shall conform to the following requirements as to dimensions:

Length on top, in.	8 to 12
Width on top, in.	$3\frac{1}{2}$ to $4\frac{1}{2}$
Depth, in.	$4\frac{3}{4}$ to $5\frac{1}{4}$

III. DRESSING.

Dressing.

5. (*a*) The blocks shall be so dressed that the faces will be approximately rectangular in shape, and the ends and sides sufficiently smooth to permit the blocks to be laid with joints not exceeding $\frac{1}{2}$ in. in width at the top, and for 1 in. downward therefrom, and not exceeding 1 in. in width at any other part of the joint.

(*b*) The wearing surface of the blocks shall show no depressions more than $\frac{3}{8}$ in. deep, and the edges and corners shall be unchipped and unbroken.

IV. INSPECTION.

Inspection.

6. (*a*) At least six blocks shall be selected for physical tests by the engineer or his authorized representative, subsequent to delivery at the place of use, so as to fairly represent actual deliveries. No sample shall include blocks that would be rejected by a visual examination. The bedding plane shall be marked on at least two of the blocks selected.

(*b*) All deliveries shall be subjected to further inspection at the place of use, prior to and during laying. All blocks which fail to conform to the requirements of Sections 1, 5 and 6 shall be rejected.

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[1] 1918 Book of A.S.T.M. Standards.

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TENTATIVE SPECIFICATIONS
FOR
SELECTED STRUCTURAL DOUGLAS FIR BRIDGE AND TRESTLE TIMBERS.[1]

Serial Designation: D 23 – 16 T.

These specifications are issued under the fixed designation D 23; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916.

I. DEFINITIONS.

Definitions. 1. The following definitions are used in connection with these specifications:

(*a*) *Annual Ring.*—Each annual ring is composed of two distinct types of wood structure, namely, the porous, light colored and light weight spring wood formed during the first part of the growing season and the hard, dense and darker colored summer wood formed during the latter part of the growing season.

(*b*) *Summer Wood.*—Summer wood is the hard, dense portion of the annual ring. It is darker in color than the more porous spring wood.

(*c*) *Sound and Tight Knot.*—A sound and tight knot is one which is solid across its face and which is as hard as the wood surrounding it; and is so fixed by growth or position that it will retain its place in the piece.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. Hermann von Schrenk, Chairman of Committee D-7 on Timber, Tower Grove and Flad Avenue, St. Louis, Mo.

(*d*) *Encased Knot.*—An encased knot is one whose growth rings are not intergrown and homogeneous with the growth rings of the piece it is in. The encasement may be partial or complete; if intergrown partially or so fixed by growth or position that it will retain its place in the piece, it shall be considered a sound and tight knot.

(*e*) *Loose Knot.*—A loose knot is one not firmly held in place by growth or position.

(*f*) *Rotten Knot.*—A rotten knot is one not as hard as the wood it is in.

(*g*) *Measurement of Knots.*

In Beams, the diameter of a knot on the narrow or horizontal face shall be taken as its projection on a line perpendicular to the edge of the timber. On the wide or vertical face, the smallest dimension of a knot is to be taken as its diameter.

In Columns, the diameter of a knot on any face shall be taken as its projection on a line perpendicular to the edge of the timber.

(*h*) *Diagonal Grain.*—(Including cross and spiral grain). Diagonal grain is grain not parallel with all the edges of the piece.

(*i*) *Dense and Sound Douglas Fir.*—Under this heading two classes of timber are designated: (1) Dense Douglas fir and (2) sound Douglas fir. It is understood that these two terms are descriptive of the quality of the clear wood.

(*j*) *Dense Douglas Fir.*—Dense Douglas fir shall show on either one end or the other an average of at least 6 annual rings per inch or 18 rings in three inches and at least 33⅓ per cent summer wood, as measured over the third, fourth and fifth inches on a radial line from the pith, for girders not exceeding 20 in. in height, and for columns 16 in. square or less. For larger timbers the inspection shall be made over the central three inches on the longest radial line from the pith to the corner of the piece. Wide-ring material excluded by the above will be accepted provided the amount of summer wood as above measured shall be at least 50 per cent.

In cases where timbers do not contain the pith, and it is impossible to locate it with any degree of accuracy, the same inspection shall be made over three inches on an approximate radial line beginning at the edge nearest the pith.

The radial line chosen shall be representative. In case of disagreement between purchaser and seller as to what is a representative radial line, the average summer wood and number of rings shall be the average of the two radial lines chosen.

(*k*) *Sound Douglas Fir.*—Sound Douglas fir shall include pieces of Douglas fir without any ring or summer wood requirement.

II. GENERAL REQUIREMENTS.

General Requirements.

2. (*a*) The timber shall be only "Dense Douglas Fir" as defined in Section 1 (*j*).

(*b*) The timber shall be well manufactured, square edge and sawed standard size; solid and free from defects such as ring shakes and injurious diagonal grain, loose or rotten knots, knots in groups, decay, pitch pockets over 6 in. long or ⅜ in. wide, or other defects that will materially impair its strength.

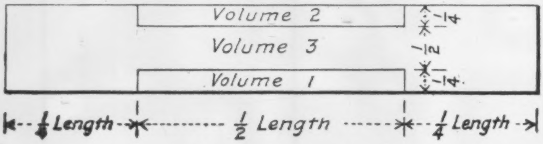

FIG. 1.

(*c*) Occasional variation in sawing, not to exceed ¼ in. scant at the time of manufacture, will be allowed.

(*d*) When timbers 4 by 4 in. and larger are ordered sized, they shall be ½ in. less than rough size, either S1S1E or S4S, unless otherwise specified.

III. STRINGERS, GIRDERS AND DEEP JOISTS.

Stringers, Girders and Deep Joists.

3. The timber shall show not less than 85 per cent of heart on each of the four sides, measured across the sides anywhere in the length of the piece. It shall not have in volumes 1 and 2 (Fig. 1) knots greater in diameter than one-fourth the width of the face in which they occur with a maximum of 1½ in. in diameter. It shall not have in volume 3 (Fig. 1) knots larger than one-third the width of the face in which they occur, with a maximum of 3 in. in diameter. Knots within the center half

of the span shall not exceed in the aggregate the width of the face in which they occur. Diagonal grain in volumes 1 or 2 with a slope greater than 1 in 20 will not be permitted. When stringers are of two-span length they shall be considered as two separate pieces and the above restrictions applied to each half. The inspector shall place his stamp on the edge of the stringer to be placed "up" in service.

IV. CAPS AND SILLS.

Caps and Sills.

4. The timber shall show 85 per cent of heart on each of the four sides, measured across the sides anywhere in the length of the piece, and shall be free from knots larger than one-fourth the width of the face in which they occur, with a maximum of 3 in. in diameter. Knots shall not be in groups.

V. POSTS.

Posts

5. The timber shall show not less than 85 per cent of heart on each of the four sides, measured across the face anywhere in the length of the piece, and shall be free from knots larger than one-fourth the width of the face in which they occur, with a maximum of 3 in. in diameter. Knots shall not be in groups.

VI. LONGITUDINAL STRUTS OR GIRTS.

Longitudinal Struts or Girts.

6. The timber shall show all heart on one face; the other face and two sides shall show not less than 85 per cent of heart, measured across the face or side anywhere in the length of the piece, and shall be free from knots over 2 in. in diameter.

VII. LONGITUDINAL X-BRACES, SASH BRACES AND SWAY BRACES.

Longitudinal X-Braces, Sash Braces and Sway Braces.

7. The timber shall show not less than 85 per cent of heart on two faces and shall be free from knots larger than one-third the width of the face in which they occur, with a maximum of 2 in. in diameter.

VIII. BRANDING.

Branding.

8. The inspector shall brand each timber which conforms to the above requirements "Selected Structural Douglas Fir."

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TENTATIVE SPECIFICATIONS
FOR
SOUTHERN YELLOW-PINE TIMBER TO BE CREOSOTED.[1]

Serial Designation: D 24 – 15 T.

These specifications are issued under the fixed designation D 24; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1915.

General Requirements. 1. The specifications as to strength shall agree with the requirements that will be finally adopted by the Society under the Standard Definitions of Terms Relating to Structural Timber (Serial Designation: D 9);[2] that is, number of rings per inch or some substitute therefor.

(Included in this section will also be a list of the allowable defects, etc.)

Sapwood. 2. All pieces shall show at least 30 per cent sapwood in cross-section. This is based on a minimum treatment of 12 lb. of creosote per cubic foot of timber.

Bridge Stringers. 3. In bridge stringers knots greater than 1½ in. in diameter shall be at least 4 in. from the edges of the stick. There shall be no knots more than 4 in. in greatest diameter in any part of the stick.

Caps and Sills. 4. Caps, sills, posts and sawed poles shall be free from knots more than 2½ in. in diameter.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. Hermann von Schrenk, Chairman of Committee D-7 on Timber, Tower Grove and Flad Avenue, St. Louis, Mo.

[2] 1918 Book of A.S.T.M. Standards.

Bracing. 5. Longitudinal bracing, cross-arms and similar pieces having small cross-section shall have no knots more than 1 in. in diameter.

Track Ties. 6. Track ties shall show at least 20 per cent sapwood in cross-section. This is based on a minimum full-cell treatment of 8 lb. of creosote per cubic foot of timber.

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TENTATIVE SPECIFICATIONS FOR SOUTHERN YELLOW-PINE PILES AND POLES TO BE CREOSOTED.[1]

Serial Designation: D 25 – 15 T.

These specifications are issued under the fixed designation D 25; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1915.

General Requirements. 1. The specifications as to strength shall agree with the requirements that will be finally adopted by the Society under the Standard Definitions of Terms Relating to Structural Timber (Serial Designation: D 9);[2] that is, number of rings per inch or some substitute therefor.

(Included in this section will also be a list of the allowable defects, etc.)

Sapwood. 2. All piles or telegraph poles shall show 40 per cent sapwood in cross-section, or there shall be a ring of sapwood not less than 1 in. in thickness all around the heartwood.

Quality. 3. (*a*) Piles and poles shall be cut from sound live trees, of straight grain and regular taper; without crooks exceeding one-fourth the diameter of the stick at middle of crook when peeled. They shall be free from rot, red heart, holes or rotten knots, shakes and felling checks.

(*b*) All piles and poles shall have the bark and inner skin carefully removed when the tree is felled; all limbs and knots trimmed flush and butts cut square.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. Hermann von Schrenk, Chairman of Committee D-7 on Timber, Tower Grove and Flad Avenue, St. Louis, Mo.

[2] 1918 Book of A.S.T.M. Standards.

Minimum Diameter.

4. The minimum diameter of piles after peeling shall be as follows:

LENGTH.	BUTTS, IN.	TOPS, IN.
36 ft. and under	14	10
38 ft. and under 50 ft	14	9
50 ft. and over	15	9

No pile with butt diameter over 18 in., nor top diameter over 13½ in., will be accepted. The length of each pile is to be legibly marked on the butt with white or black paint.

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TENTATIVE SPECIFICATIONS FOR WOODEN PAVING BLOCKS FOR EXPOSED PAVEMENTS.[1]

Serial Designation: D 52 – 18 T.

These specifications are issued under the fixed designation D 52; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1918.

Material Covered.

1. These specifications cover wooden paving blocks for pavements exposed to alternate wet and dry conditions, as distinguished from pavements which are used under cover and protected from atmospheric influences.

I. TIMBER.

Kind of Timber.

2. The wood, which shall be treated, shall be Southern yellow pine, Douglas fir, tamarack, Norway pine, hemlock, or black gum. Only one kind of wood shall be used in any one contract. The blocks shall be sound, and shall be well manufactured, square-butted, square-edged, free from unsound, loose or hollow knots, knot holes, worm holes, and other defects such as shakes, checks, etc., that would be detrimental to the blocks.

Quality of Timber.

3. The number of annual rings in the one inch which begins two inches from the pith of the block shall not be less than six, measured radially; provided, however, that blocks

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably, before January 1, 1920, to Mr. Hermann von Schrenk, Chairman of Committee D-7 on Timber, Tower Grove and Flad Avenue, St. Louis, Mo.

containing between five and six rings in this inch shall be accepted if they contain $33\frac{1}{3}$ per cent or more summerwood. In case the block does not contain the pith, the one inch to be used shall begin one inch away from the ring which is nearest to the heart of the block. The blocks in each charge shall contain an average of at least 70 per cent of heart wood. No one block shall be accepted that contains less than 50 per cent of heart wood.

Size of Blocks.

4. The blocks shall be from 5 to 10 in. long, but should preferably average two times the depth; they shall be .... in. in depth.[1] They may be from 3 to 4 in. in width, but in any one city block all of them shall be of uniform width. A variation of $\frac{1}{16}$ in. shall be allowed in the depth and $\frac{1}{8}$ in. in the width of the blocks from that specified. In all cases the width shall be greater or less than the depth by at least $\frac{1}{2}$ in.

II. TREATMENT.

Treatment.

5. The timber may be either air-seasoned or green, but should preferably be treated within three months from the time it is sawed. Green timber and seasoned timber shall not, however, be treated together in the same charge. The blocks shall be treated in an air-tight cylinder with the preservative specified by the purchaser. In all cases, whether thoroughly air-seasoned or green, they shall first be subjected to live steam at a temperature between 220 and 240° F.[2] for not less than 2 hours nor more than 4 hours, at the discretion of the treating plant operator, after which they shall be subjected to a vacuum of not less than 22 in. held for at least one hour. While the vacuum is still on, the preservative oil, heated to a temperature of between 180 and 220° F., shall be run in until the cylinder is completely filled, care being taken that no air is admitted. Pressure shall then be gradually applied not to exceed 50 lb. at the end of the first hour nor 100 lb. at the end of the second hour, and then maintained at not less than 100 lb. nor more than 150 lb. until the wood has absorbed the required amount of oil.[3]

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[1] It is recommended that blocks 4 in. in depth be used for streets with very heavy traffic, and blocks $3\frac{1}{2}$ in. in depth for streets with moderate traffic. For streets with light traffic blocks 3 in. in depth may be used, but where 3-in. blocks are used no block shall be longer than 8 in.

[2] In no case shall a steam pressure of 20 lb. per sq. in. be exceeded.

[3] This treatment is recommended for yellow pine only. It is probably also suited to Norway pine, hemlock, black gum and tamarack, but not to Douglas fir. Further recommendations on the treatment of these species are reserved for the future.

After this a supplemental vacuum, in which the maximum intensity reached is at least 20 in. and the time the vacuum is applied not less than 30 minutes, shall be applied. If desired, this vacuum may be followed by a short steaming period.

Penetration of Preservative.

6. In any charge blocks shall contain at least 16 lb. of water-free oil per cubic foot of wood at the completion of the treatment. The blocks after treatment shall show satisfactory penetration of the preservative, and in all cases the oil shall be diffused throughout the sap wood. To determine this, at least 25 blocks shall be selected from various parts of each charge and sawed in half perpendicular to the fibers through the center, and if more than one of these blocks show untreated sap wood, the charge shall be re-treated. After re-treating, the charge shall be again subjected to a similar inspection.

Handling Blocks After Treatment.

7. Blocks shall preferably be laid in the street as soon as possible after being treated. If they cannot be laid immediately, provision shall be made to prevent them from drying out by stacking in close piles and covering them, and, if possible, by sprinkling them thoroughly at intervals. In any case, where they are not laid as soon as they are received on the street, they shall be well sprinkled about two days before being laid, under the direction of the purchaser. It is important to have the wood sufficiently wet to be swelled to its maximum size before it is laid.

III. PRESERVATIVE.

Preservatives.

8. The preservative used shall be coal-tar paving oil or distillate oil, as specified by the purchaser.

Coal-Tar Paving Oil.

9. The coal-tar paving oil shall be a coal-tar product, of which at least 65 per cent shall be a distillate of coal-gas tar or coke-oven tar and the remainder shall be refined or filtered coal-gas tar or coke-oven tar.

It shall conform to the following requirements:

(*a*) It shall not contain more than 3 per cent of water.

(*b*) It shall not contain more than 3 per cent of matter insoluble in benzol.

(*c*) The specific gravity of the oil at 38° C. shall not be less than 1.07 nor more than 1.14.

(*d*) The distillates, based on water-free oil, shall be within the following limits:

Up to 210° C. . . . . not more than 5 per cent.
" " 235° C. . . . . " " " 25 "

The residue above 355° C., if it exceeds 35 per cent, shall have a float test of not more than 80 seconds at 70° C.

(*e*) The specific gravity of the fraction between 235 and 315° C. shall not be less than 1.03 at 38°/15°.5 C.

The specific gravity of the fraction between 315 and 355° C. shall not be less than 1.09 at 38°/15°.5 C.

(*f*) The oil shall yield not more than 10 per cent coke residue.

Distillate Oil.

10. The distillate oil shall be a distillate of coal-gas tar or coke-oven tar.

It shall conform to the following requirements:

(*a*) It shall not contain more than 3 per cent of water.

(*b*) It shall not contain more than 0.5 per cent of matter insoluble in benzol.

(*c*) The specific gravity of the oil at 38° C. shall not be less than 1.06.

(*d*) The distillates, based on water-free oil, shall be within the following limits:

Up to 210° C. . . . . not more than 5 per cent.
" " 235° C. . . . . " " " 15 "

The residue above 355° C., if it exceeds 10 per cent, shall have a float test of not more than 50 seconds at 70° C.

(*e*) The specific gravity of the fraction between 235 and 315° C. shall not be less than 1.03 at 38°/15°.5 C.

The specific gravity of the fraction between 315 and 355° C. shall not be less than 1.09 at 38°/15°.5 C.

(*f*) The oil shall yield not more than 2 per cent coke residue.

IV. INSPECTION.

Inspection at Plant.

11. All material herein specified and processes used in the manufacture of the blocks therefrom shall be subject to inspection, acceptance, or rejection at the plant of the manufacturer, which shall be equipped with all the necessary gages, appliances,

and facilities to enable the inspector to satisfy himself that the requirements of the specifications are being fulfilled.

Inspection at Street.

12. The purchaser shall have the further right to inspect the blocks after delivery upon the street, for the purpose of rejecting any blocks that do not meet these specifications; except that the plant inspections shall be final with respect to the kind of wood, number of rings per inch, oil, and treatment.

NOTE.

The following specifications for water-gas tar are presented for information:

SPECIFICATIONS FOR WATER-GAS TAR.

The preservative shall be a refined water-gas tar. It shall comply with the following requirements:

1. It shall contain not more than 3 per cent of water.
2. It shall contain not more than 2 per cent of matter insoluble in benzol and chloroform.
3. The specific gravity of the preservative at 38°/15°.5 C. shall not be less than 1.110 nor more than 1.140.
4. The distillates, based on water-free oil, shall be within the following limits:

Up to 210° C.	not more than	5 per cent.
" " 235° C.	" " "	15 "
" " 315° C.	" " "	40 "
" " 355° C.	" less "	25 "

5. The specific gravity of the total distillate below 355° C. shall not be less than 0.99, nor more than 1.03 at 38°/15°.5 C.

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TENTATIVE SPECIFICATIONS
FOR
ASPHALT FOR USE IN DAMP-PROOFING AND WATERPROOFING.[1]

Serial Designation: D 40 - 17 T.

These specifications are issued under the fixed designation D 40; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

Material Covered. 1. These specifications cover asphalt for use in damp-proofing and waterproofing, designated as type A, recommended for use under uniformly moderate temperature conditions.

I. PROPERTIES.

Melting Point. 2. The melting point shall be between 38 and 60° C. (100 and 140° F.) as determined by the ring-and-ball method in water bath, and shall be specified for one of the following classes: 54.5 to 60° C. (130 - 140° F.); 46 to 54°.5 C. (115 - 130° F.); 38 to 46° C. (100 - 115° F.). The Standard Method for Determination of Softening Point of Bituminous Materials other than Tar Products (Serial Designation: D 36) of the American Society for Testing Materials[2] shall be used.

Penetration. 3. The penetration at 25° C. (77° F.) under load of 100 g.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. Leroy M. Law, Secretary of Committee D-8 on Waterproofing, Interocean Oil Co., East Brooklyn, Baltimore, Md.

[2] Supplementary Pamphlet of A.S.T.M. Standards Adopted in 1919.

for 5 seconds, as determined by the Standard Test for Penetration of Bituminous Materials (Serial Designation: D 5) of the American Society for Testing Materials,[1] shall be not less than 50 nor more than 125.

The penetration shall bear the following relation to the melting point:

Penetration of 50 to 75 for melting points between 54.5 and 60° C. (130 and 140° F.).
Penetration of 75 to 100 for melting points between 46 and 54°.5 C. (115 and 130° F.).
Penetration of 100 to 125 for melting points between 38 and 46° C. (100 and 115° F.).

Ductility. 4. The ductility[2] at 25° C. (77° F.), when a briquette of the material having a minimum cross-section of 1 sq. cm. is pulled apart at the rate of 5 cm. per minute, shall not be less that 30 cm.

Specific Gravity. 5. The specific gravity shall not be more than 1.08 at 25/25° C. (77/77° F.).

Soluble in Carbon Bisulfide. 6. The bitumen soluble in cold carbon bisulfide, as determined by the method in Section 10, shall not be less than 95 per cent.

Loss on Heating. 7. The loss of a 50-g. sample on heating at 163° C. (325° F.) for 5 hours, as determined by the Standard Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6) of the American Society for Testing Materials,[1] shall not exceed 1 per cent. The penetration of the residue from this test shall be not less than 50 per cent of the original penetration specified in Section 3.

Ash. 8. The ash, as determined by the method in Section 10, shall not exceed 4 per cent.

II. METHODS OF TESTING.

9. *Specific Gravity.*—The specific gravity may be determined by any approved method, but some method similar to the following is recommended:

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[1] 1918 Book of A.S.T.M. Standards.

[2] A detailed description of the mold and method to be followed is given in Appendix IV, Report of Committee D-4 on Road Materials, *Proceedings*, Am. Soc. Test. Mats., Vol. XV, Part I, p. 349 (1915).

Weigh accurately in air a small platinum pan or crucible supported in a wire sling and suspended by a fine platinum wire or silk thread; record the weight as weight A. Then weigh it in a like manner completely immersed in freshly distilled water at 25° C. (77° F.) except for the fine platinum wire or silk thread. Record this weight as weight B. Then bring the crucible to red heat, cool and almost fill with asphalt which has been melted at the lowest possible temperature. Cool the crucible and contents to room temperature, place in the sling and weigh in air. Record the weight as weight C. Then weigh crucible and contents at 25° C. (77° F.) suspended as before in water, and record this weight as weight D. From these four weights the specific gravity may be calculated from the following formula:

$$\text{Specific Gravity} = \frac{C-A}{(C-A)-(D-B)}.$$

10. *Bitumen Soluble in Cold Carbon Bisulfide; Ash.*—For this test weigh accurately 1 to 2 g. of asphalt into an Erlenmeyer flask. Pour 100 cc. of c. p. carbon bisulfide into the flask in small portions, with continual agitation, until all lumps disappear and nothing adheres to the bottom. Cork the flask and set aside for 15 minutes. Then filter the solution by suction through an asbestos pad in a Gooch crucible (the best size of crucible for this test is 4.4 cm. wide at the tod tapering to 3.6 cm. at the bottom, and 2.5 cm. deep), which has been previously prepared and weighed. Care shall be exercised in decanting the liquid portion. Stop the decantation at the first sign of sediment coming out. Wash the sides of the flask with a small amount of fresh carbon bisulfide and bring the sediment upon the felt, using a "policeman," if necessary, to remove all adhering material. Then wash the material on the mat with carbon bisulfide until the washings are colorless and continue suction until the odor of carbon bisulfide is hardly detectable. Then clean the outside of the crucible with a cloth moistened with a small amount of solvent. Dry the crucible with contents for one-half hour at 105° C. (221° F.), cool in a desiccator and weigh.

The total weight of insoluble material includes both organic and inorganic insoluble. If organic insoluble material is present, heat the crucible to red heat until no carbonaceous particles remain,—leaving only the mineral ash,—cool and weigh. The percentage soluble in carbon bisulfide, the organic insoluble, if there is any present, and the ash should total 100 per cent. Each should be reported.

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TENTATIVE SPECIFICATIONS
FOR
PRIMER FOR USE WITH ASPHALT FOR USE IN DAMP-PROOFING AND WATERPROOFING.[1]

Serial Designation: D 41 – 17 T.

These specifications are issued under the fixed designation D 41; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

Material Covered. 1. These specifications cover primer for use, when specified, with asphalt for use in damp-proofing and waterproofing.

Primer. 2. The primer shall consist of an asphaltic base, complying in every respect with the Tentative Specifications for Asphalt for Use in Damp-proofing and Waterproofing (Serial Designation: D 40 – 17 T) of the American Society for Testing Materials[2] for use below grade, which shall be thinned to ordinary paint consistency with a petroleum distillate having an end point on distillation not above 260° C. (500° F.). Not more than 20 per cent of this petroleum distillate shall distill under 120° C. (248° F.).

The distillation shall be carried out according to the Standard Tests for Paint Thinners other than Turpentine (Serial Designation: D 28) of the American Society for Testing Materials.[3]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. Leroy M. Law, Secretary of Committee D-8 on Waterproofing, Interocean Oil Co., East Brooklyn, Baltimore, Md.

[2] See p. 669.

[3] 1918 Book of A.S.T.M. Standards.

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TENTATIVE SPECIFICATIONS FOR COAL-TAR PITCH FOR USE IN DAMP-PROOFING AND WATERPROOFING.[1]

Serial Designation: D 42 – 17 T.

These specifications are issued under the fixed designation D 42; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

Material Covered. 1. These specifications cover coal-tar pitch for use in damp-proofing and waterproofing, designated as type A, recommended for use under uniformly moderate temperature conditions.

I. PROPERTIES.

Melting Point. 2. The melting point, as determined by the cube method in water bath, Section 9, shall be between 49 and 60° C. (120 and 140° F.). In specifying the melting point desired within the above limits, a variation of not more than 2°.5 C. (5° F.) in either direction will be permitted.

Penetration 3. The penetration at 25° C. (77° F.) under load of 100 g. for 5 seconds, as determined by the Standard Test for Penetration of Bituminous Materials (Serial Designation: D 5) of the American Society for Testing Materials,[2] shall not be less than 20 nor more than 120.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. Leroy M. Law, Secretary of Committee D-8 on Waterproofing, Interocean Oil Co., East Brooklyn, Baltimore, Md.

[2] 1918 Book of A.S.T.M. Standards.

Ductility. 4. The ductility[1] at 25° C. (77° F.). when a briquette of the material having a minimum section of 1 sq. cm. is pulled apart at the rate of 5 cm. per minute, shall not be less than 40 cm.

Loss on Heating. 5. The loss of a 20-g. sample on heating at 163° C. (325° F.) for 5 hours, as determined by the Standard Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6) of the American Society for Testing Materials,[2] on pitch of melting point between 49 and 54°.5 C. (120 and 130° F.) shall not exceed 9 per cent and on pitch of melting point between 54.5 and 60° C. (130 and 140° F.) shall not exceed 7 per cent.

Specific Gravity. 6. The specific gravity of the pitch at 25/25° C. (77/77° F.) shall not exceed the limits 1.24 and 1.34.

The specific gravity at 60/60° C. (140/140° F.) of the distillate to 355° C. (671° F.) shall not be less than 1.06.

Soluble Matter. 7. The matter soluble in hot toluol-benzol, as determined by the method in Section 12, shall not be less than 65 nor more than 85 per cent.

Ash. 8. The ash, as determined by the method in Section 13, shall not exceed 1 per cent.

II. METHODS OF TESTING.

9. *Melting Point.*—The melting point shall be the temperature at which the pitch formed in a $\frac{1}{2}$-in. cube and suspended in a vessel of water 1 in. above the bottom shall touch the bottom of this vessel. The cube is formed by pressing the pitch in a suitable mold. Remove the cube from the mold and suspend on the lower arm of a No. 12 B. & S. gage wire bent at right angles. The wire should be passed through the center of two opposite faces of the cube. Immerse the cube in 400 cc. of freshly boiled distilled water at a temperature of 15°.5 C. (60° F.) contained in a 600-cc. beaker. Maintain this temperature until the pitch is the same temperature as the water. Apply heat in such a manner that the temperature of the water is raised 5° C. (9° F.) per minute, until the pitch touches the bottom of the beaker. At this point the temperature, recorded

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[1] A detailed description of the mold and method to be followed is given in **Appendix IV**, Report of Committee D-4 on Road Materials, *Proceedings*, Am. Soc. Test. **Mats., Vol. XV, Part I**, p. 349 (1915).

[2] 1918 Book of A.S.T.M. Standards; use a 20-g. sample instead of **the 50-g. sample specified.**

by a thermometer whose bulb shall be level with the cube, shall be considered as the melting point of the pitch.

10. *Specific Gravity.*—The specific gravity may be determined by any approved method, but some method similar to the following is recommended:

Weigh accurately in air a small platinum pan or crucible supported in a wire sling and suspended by a fine platinum wire or silk thread; record the weight as weight A. Then weigh it in a like manner completely immersed in freshly distilled water at 25° C. (77° F.), except for the fine platinum wire or silk thread. Record this weight as weight B. Then bring the crucible to red heat, cool and almost fill with pitch which has been melted at the lowest possible temperature. Cool the crucible and contents to room temperature, place in the sling and weigh in air. Record the weight as weight C. Then weigh crucible and contents at 25° C. (77° F.) suspended as before in water, and record this weight as weight D. From these four weights the specific gravity may be calculated from the following formula:

$$\text{Specific Gravity} = \frac{C-A}{(C-A)-(D-B)}.$$

11. *Specific Gravity of Distillate.*—Distill in a glass or metal retort, preferably of 8-oz. capacity, at least 100 g. of the pitch to 355° C. (671° F.) vapor temperature, catching the distillate. The specific gravity may be determined by any approved method, but the following is recommended:

Clean a 10-cc. specific-gravity bottle; dry and weigh. Fill it with distilled water and heat to 60° C. (140° F.) as described below; dry and weigh. Then fill the bottle with distillate, immerse in water and heat slowly to 60° C. (140° F.), maintaining this temperature for at least 5 minutes. Dry, cool and weigh. From these weights the specific gravity may be determined from the following formula:

$$\text{Specific Gravity} = \frac{\text{Weight of bottle} + \text{distillate} - \text{weight of bottle.}}{\text{Weight of bottle} + \text{water} - \text{weight of bottle}}$$

12. *Matter Insoluble in Hot Toluol-Benzol Extraction.*[1]—In

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[1] A full description of a simple apparatus for this test may be found in the *Journal of Industrial and Engineering Chemistry*, Vol. 6, pp. 279–285.

testing materials of 5 per cent or more insoluble matter 5 g. should be taken for the test. With lesser percentages 10 g. should be used. Weigh out the amount in a 100-cc. beaker, and digest with about 50 cc. of c. p. toluol on the steam bath, for a period not to exceed 30 minutes. If the solution is kept hot and constantly stirred, the digestion can be completed very rapidly. Weigh a filter cup, previously prepared, in a weighing bottle and place in a carbon filter tube over a beaker or flask. Decant the toluol-tar mixture through the thimble and wash with hot c. p. toluol until clean, using some form of "policeman" which is unaffected by toluol, for the purpose of detaching any residue which may adhere to the beaker. Finally, wash the cup with hot c. p. benzol and then, after draining, cover with a cap of filter paper or alundum, and place in the extraction apparatus in which the c. p. benzol is used as solvent. Continue the extraction until the descending benzol is colorless. Remove the thimble, take off the cap, dry in the steam oven and weigh in the weighing bottle after cooling in the desiccator. The balance used for this work should be accurate to at least ½ mg. It is well to examine the insoluble residue for foreign matter such as wood, slivers, pieces of bagging, etc. If such foreign matter is present, the test should be rejected.

13. *Ash.*—This determination is made by burning to ash a 1-g. sample of the material in a weighed platinum crucible or dish of sufficient size. Apply heat gently until the pitch ignites, then withdraw the heat. After the pitch ceases to burn, apply the heat again until the residue is burned free of carbon. Then cool the crucible and contents, weigh, and determine the ash.

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TENTATIVE SPECIFICATIONS FOR CREOSOTE OIL FOR PRIMING COAT WITH COAL-TAR PITCH FOR USE IN DAMP-PROOFING AND WATERPROOFING.[1]

Serial Designation: D 43 – 17 T.

These specifications are issued under the fixed designation D 43; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

Material Covered. 1. When it is specified that previous to the mopping on of the hot coal-tar pitch, the wall, floor, or foundation shall be painted with a priming coat, the following specifications for creosote oil shall apply:

Definition. 2. Creosote oil shall be a pure tar distillate free from any substance foreign to a tar distillate.

Melting Point. 3. The oil shall be entirely fluid at 38° C. (100° F.).

Specific Gravity. 4. The specific gravity at 38° C. (100° F.) shall not be less than 1.00 nor more than 1.06.

Insoluble Matter. 5. Insoluble matter in hot benzol shall be less than 1 per cent.

Distillation. 6. When distilled in accordance with the Standard Methods for Sampling and Analysis of Creosote Oil (Serial Designation: D 38) of the American Society for Testing Materials,[1] it shall yield:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. Leroy M. Law, Secretary of Committee D-8 on Waterproofing, Interocean Oil Co., East Brooklyn, Baltimore, Md.

(*a*) Water, not more than 2 per cent.

(*b*) Not more than 5 per cent shall distill under 200° C. (392° F.).

(*c*) Not more than 50 nor less than 30 per cent shall distill under 235° C. (455° F.).

(*d*) The residue above 355° C. (671° F.) shall not exceed 15 per cent.

(*e*) The residue shall be soft.

(*f*) The specific gravity at 38° C. (100° F.) of the fraction distilling between 235 and 315° C. (455 and 599° F.) shall not be less than 1.00.

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[1] 1918 Book of A.S.T.M. Standards.

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TENTATIVE SPECIFICATIONS
FOR
CANNED FOODS BOXES, NAILED AND LOCK-CORNER CONSTRUCTION.[1]

Serial Designation: D 44 – 17 T.

These specifications are issued under the fixed designation D 44; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

I. MANUFACTURE.

Manufacture. 1. Boxes shall be well manufactured from sound (free from decay or dote), well-seasoned lumber. Boxes when stored after nailing should not be placed in a heated room. Lumber shall be free from knot holes, loose or rotten knots greater than 1 in. in diameter. No knots will be permitted which will interfere with the proper nailing of the box.

Cleating. 2. Cleats shall be $1\frac{1}{8}$ by $\frac{3}{8}$ in., or any other size that has equally large cross section, with six nails to each cleat driven through and clinched. No piece of end shall have less than two nails. The outside nails shall be driven as near the ends of cleats as possible without splitting the cleat; the remainder of the nails shall be as evenly spaced as possible. No nail shall be driven in a joint.

Nailing. 3. Nails shall be as evenly spaced as possible, and no nail shall be driven in a joint. All nails shall be driven squarely into the center of the thickness of the end. There shall be at least two nails in each end of any one piece of lumber.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. W. S. Topping, Secretary of Committee D-10 on Shipping Containers, 30 Vesey St., New York City.

Outside nails on the sides shall be driven just inside the end nails of the cleats.

Outside nails on the top and bottom shall be driven far enough inside to miss the side nails.

The sides, tops and bottoms shall be flush with the ends.

The tops and bottoms shall overlap the sides.

The size of nails shall depend on the woods used for the ends.

II. DIVISION BY SPECIES OF WOOD.

(*A*) *Group I.*[1]

Group I.

4. Group I shall comprise the following species of wood:

White pine
Aspen
Western yellow pine
Spruce
Cottonwood
Yellow poplar
Balsam fir
Chestnut
Sugar pine
Basswood
Cypress
Willow
Noble fir
Magnolia
Buckeye
White fir
Cedar
Redwood
Butternut
Cucumber
Alpine fir
Lodgepole pine

Nos. 2½ and 3 Cans, Group I.

5. Boxes for two dozen No. 2½, two dozen No. 3, and two dozen extra size No. 3 cans shall be constructed as follows:

(*a*) *Nailed Construction.*—The ends shall be $\frac{5}{8}$ in. thick, and of one or two pieces. Two-piece ends shall be cleated or fastened with three 1 by $\frac{3}{8}$-in. corrugated steel fasteners, driven transversely with the grain. When one-piece sides are used the third corrugated fastener may be omitted.

The sides, tops and bottoms shall be of sawed lumber $\frac{5}{16}$ in. thick, not more than two pieces to each side or three pieces to each top or bottom. No piece shall be less than 2 in. in width.

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[1] When one-piece sides and two-piece tops and bottoms of sawed lumber are used, material $\frac{1}{32}$ in. thinner will be permitted. The thicknesses specified herein are to allow for an occasional unavoidable variation in manufacture, but that variation shall not exceed $\frac{1}{64}$ in. below the thicknesses specified.

There shall be seven 6*d* standard, cement-coated box nails, not less than $1\frac{13}{16}$ in. in length, to each nailing edge.

(*b*) *Lock-Corner Construction.*—The ends shall be $\frac{5}{8}$ in. thick and the sides, top and bottom $\frac{5}{16}$ in. thick. All piecing shall be tongued, grooved and glued. The top and bottom shall be nailed with not less than fourteen 6*d* standard, cement-coated box nails in each top and each bottom.

Nos. 1 and 2 Cans, Group I.

6. Boxes for two dozen No. 1, four dozen No. 1, and two dozen No. 2 cans shall be constructed as follows:

(*a*) *Nailed Construction.*—The ends shall be $\frac{5}{8}$ in. thick, and of one or two pieces. Two-piece ends shall be cleated or fastened with two 1 by $\frac{3}{8}$-in. corrugated steel fasteners, driven transversely with the grain.

The sides, tops and bottoms shall be of sawed lumber $\frac{5}{16}$ in. thick, not more than two pieces to each side or three pieces to each top or bottom. No piece shall be less than 2 in. in width.

There shall be six 6*d* standard, cement-coated box nails, not less than $1\frac{13}{16}$ in. in length, to each nailing edge.

(*b*) *Lock-Corner Construction.*—The ends and sides shall be at least $\frac{7}{16}$ in. thick, and the top and bottom $\frac{5}{16}$ in. thick; or $\frac{1}{2}$-in. ends may be used with $\frac{5}{16}$-in. sides, top and bottom. All piecing shall be tongued, grooved and glued, and the top and bottom shall be nailed with not less than twelve 4*d* standard, cement-coated box nails in each top and each bottom.

(*B*) *Group II.*[1]

Group II.

7. Group II shall comprise the following species of wood:

Southern yellow pine
Hemlock
Virginia and Carolina pine
Douglas fir
Larch

Nos. 2½ and 3 Cans, Group II.

8. Boxes for two dozen No. $2\frac{1}{2}$, two dozen No. 3, and two dozen extra size No. 3 cans shall be constructed as follows:

(*a*) *Nailed Construction.*—The ends shall be $\frac{5}{8}$ in. thick and of one or two pieces. Two-piece ends shall be cleated or fastened with three 1 by $\frac{3}{8}$-in. corrugated steel fasteners, driven transversely with the grain. When one-piece sides are used, the third corrugated fastener may be omitted.

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[1] When one-piece sides and two-piece tops and bottoms of sawed lumber are used. material $\frac{1}{32}$ in. thinner will be permitted. The thicknesses specified herein are to allow for an occasional unavoidable variation in manufacture, but that variation shall not exceed $\frac{1}{64}$ in below the thicknesses specified.

The sides, tops and bottoms shall be of sawed lumber $\frac{5}{16}$ in. thick, not more than two pieces to each side or three pieces to each top or bottom. No piece shall be less than 2 in. in width.

There shall be seven 5*d* standard cement-coated, box nails, not less than $1\frac{9}{16}$ in. in length, to each nailing edge.

(*b*) *Lock-Corner Construction.*—The ends shall be $\frac{5}{8}$ in. thick and the sides, top and bottom $\frac{5}{16}$ in. thick. All piecing shall be tongued, grooved and glued, and nailed with not less than fourteen 5*d* standard, cement-coated box nails in each top and each bottom.

Nos. 1 and 2 Cans, Group II.

9. Boxes for two dozen No. 1, four dozen No. 1, and two dozen No. 2 cans shall be constructed as follows:

(*a*) *Nailed Construction.*—The ends shall be $\frac{5}{8}$ in. thick and of one or two pieces. Two-piece ends shall be cleated or fastened with two 1 by $\frac{3}{8}$-in. corrugated steel fasteners, driven transversely with the grain.

The sides, tops and bottoms shall be of sawed lumber $\frac{5}{16}$ in. thick, not more than two pieces to each side or three pieces to each top or bottom. No piece shall be less than 2 in. in width.

There shall be six 5*d* standard, cement-coated box nails, not less than $1\frac{9}{16}$ in. in length, to each nailing edge.

(*b*) *Lock-Corner Construction.*—The ends and sides shall be at least $\frac{7}{16}$-in. thick and the top and bottom $\frac{5}{16}$ in. thick; or $\frac{1}{2}$-in. ends may be used with $\frac{5}{16}$-in. sides, top and bottom. All piecing shall be tongued, grooved and glued and the top and bottom nailed with not less than twelve 4*d* standard, cement-coated box nails in each top and each bottom.

(*C*) *Group III.*[1]

Group III.

10. Group III shall comprise the following species of wood:

White elm
Red gum
Sycamore
Pumpkin ash

Black ash
Black gum
Tupelo
Maple, soft or silver

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[1] When one-piece sides and two-piece tops and bottoms of sawed lumber are used, material $\frac{1}{32}$ in. thinner will be permitted. The thicknesses specified herein are to allow for an occasional unavoidable variation in manufacture, but that variation shall not exceed $\frac{1}{16}$ in. below the thicknesses specified.

Nos. 2½ and 3 Cans, Group III.

11. Boxes for two dozen No. 2½, two dozen No 3, and two dozen extra size No. 3 cans shall be constructed as follows:

(*a*) *Nailed Construction.*—The ends shall be ½ in. thick and of one or two pieces. Two-piece ends shall be cleated or fastened with three 1 by ⅜-in. corrugated steel fasteners, driven transversely with the grain. When one-piece sides are used, the third corrugated fastener may be omitted.

The sides, tops and bottoms shall be of sawed lumber $\frac{5}{16}$ in. thick, not more than two pieces to each side or three pieces to each top or bottom. No piece shall be less than 2 in. in width.

A veneer of Red gum ¼ in. thick shall be used with one-piece sides and tops, and one and two-piece bottoms. No piece shall be less than 2 in. in width.

There shall be seven 4*d* standard, cement-coated box nails, not less than $1\frac{5}{16}$ in. in length, to each nailing edge.

(*b*) *Lock-Corner Construction.*—The ends shall be ½ in. thick and the sides, top and bottom $\frac{5}{16}$ in. thick. All piecing shall be tongued, grooved and glued, and the top and bottom nailed with not less than fourteen 4*d* standard, cement-coated box nails in each top and each bottom.

Nos. 1 and 2 Cans, Group III.

12. Boxes for two dozen No. 1, four dozen No. 1, and two dozen No. 2 cans shall be constructed as follows:

(*a*) *Nailed Construction.*—The ends shall be ½ in. thick and of one or two pieces. Two-piece ends shall be cleated or fastened with two 1 by ⅜-in. corrugated steel fasteners, driven transversely with the grain.

The sides, tops and bottoms shall be of sawed lumber $\frac{5}{16}$ in. thick, not more than two pieces to each side or three pieces to each top or bottom. No piece shall be less than 2 in. in width.

A veneer of Red gum ¼ in. thick shall be used with one-piece sides and tops, and one and two-piece bottoms. No piece shall be less than 2 in. in width.

There shall be six 4*d* standard, cement-coated box nails, not less than $1\frac{5}{16}$ in. in length, to each nailing edge.

(*b*) *Lock-Corner Construction.*—The ends shall be ½ in. thick, and the sides, top and bottom $\frac{5}{16}$ in. thick. All piecing shall be tongued, grooved and glued and the top and bottom shall be nailed with not less than twelve 4*d* standard, cement-coated box nails in each top and each bottom.

(*D*) *Group IV.*

13. Group IV shall comprise the following species of wood: **Group IV.**

Hard maple
Beech
Oak
Hackberry
Birch
Rock elm
White ash

14. Boxes for two dozen No. 2½, two dozen No. 3, and two dozen extra size No. 3 cans shall be constructed as follows: **Nos. 2½ and 3 Cans, Group IV.**

(*a*) *Nailed Construction.*—The ends shall be ½ in. thick and of one or two pieces. Two-piece ends shall be cleated or fastened with three 1 by ⅜-in. corrugated steel fasteners, driven transversely with the grain. When one-piece sides are used, the third corrugated fastener may be omitted.

The sides, tops and bottoms shall be of sawed lumber ¼ in. thick, not more than two pieces to each side or three pieces to each top or bottom. No piece shall be less than 2 in. in width.

There shall be seven 4*d* standard, cement-coated box nails, not less than 1$\frac{5}{16}$ in. in length, to each nailing edge.

(*b*) *Lock-Corner Construction.*—The ends shall be ½ in. thick and the sides, top and bottom $\frac{5}{16}$ in. thick. All piecing shall be tongued, grooved and glued, and the top and bottom nailed with not less than fourteen 4*d* standard, cement-coated box nails in each top and each bottom.

15. Boxes for two dozen No. 1, four dozen No. 1, and two dozen No. 2 cans shall be constructed as follows: **Nos. 1 and 2 Cans, Group IV.**

(*a*) *Nailed Construction.*—The ends shall be ½ in. thick and of one or two pieces. Two-piece ends shall be cleated or fastened with two 1 by ⅜-in. corrugated steel fasteners, driven transversely with the grain.

The sides, tops and bottoms shall be of sawed lumber ¼ in. thick, not more than two pieces to each side or three pieces to each top or bottom. No piece shall be less than 2 in. in width.

There shall be six 4*d* standard, cement-coated box nails, not less than 1$\frac{5}{16}$ in. in length, to each nailing edge.

(*b*) *Lock-Corner Construction.*—The ends shall be $\frac{1}{2}$ in. thick and the sides, top and bottom $\frac{5}{16}$ in. thick. All piecing shall be tongued, grooved and glued and the top and bottom nailed with not less than twelve 4*d* standard, cement-coated box nails in each top and each bottom.

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TENTATIVE SPECIFICATIONS
FOR
CANNED FOODS BOXES, WIREBOUND CONSTRUCTION.[1]

Serial Designation: D 45 – 17 T.

These specifications are issued under the fixed designation D 45; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

I. MANUFACTURE.

Manufacture.

1. Boxes shall be well manufactured from sound (free from decay or dote), well-seasoned veneer and cleat lumber. Kiln drying by excessively high temperatures or low humidities or below 6 per cent moisture shall be avoided. Veneer shall be free from knot holes, loose or rotten knots greater than 1 in. in diameter. Cleats shall be free from knots and from excessive cross grain. No knots will be permitted which will interfere with proper nailing or stapling. Each side, top, and end shall be of a single piece of veneer; the bottoms shall consist of not more than two pieces, no piece less than 4 in. in width.

Nos. 2½ and 3 Cans.

2. Boxes for two dozen No. 2½, two dozen No. 3, and two dozen extra size No. 3 cans shall be constructed as follows:

(*a*) *Cleats.*—Each end shall be cleated with four cleats not less than $\frac{15}{16}$ by $\frac{11}{16}$ in., or any other size cleats that have equally large cross-section. One end of each cleat shall be provided with a tenon $\frac{1}{4}$ in. thick and $\frac{15}{16}$ in. long and the other end with the corresponding mortise. Cleats may be made of any of the following species of wood:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. W. S. Topping, Secretary of Committee D-10 on Shipping Containers, 30 Vesey St., New York City.

Red gum
Black gum
Maple
Birch
Beech
Tupelo
Elm
Oak
Sycamore
Ash
Hickory
Hackberry
Yellow pine

(*b*) The sides, top, bottom and ends shall be of $\frac{1}{8}$-in. gum[1] veneer. The box shall be bound with four equally spaced 16-gage 0.0625-in. diameter, basic annealed wires. End wires shall be attached to cleats with 16-gage by $1\frac{1}{8}$-in. bright, soft Bessemer staples driven through the veneer into the center of the width of the cleats. Six staples shall be driven into each top and bottom cleat and four into each side cleat. Interior wires shall be attached to the veneer by 18-gage, bright, soft Bessemer staples driven through and clinched; six staples connecting each wire to top and bottom and four to each side.

(*c*) The ends shall be attached to each side cleat by four 18-gage by $\frac{13}{16}$-in. staples equally spaced, driven into the center of the cleat and at an angle of 45 to 60 deg. with the grain of the end; or by four nails $\frac{7}{8}$-in. by 15-gage by $\frac{1}{4}$-in. head, driven into the center of the cleat and equally spaced.

Nos. 1 and 2 Cans.

3. Boxes for two dozen No. 1, four dozen No. 1, and two dozen No. 2 cans shall be constructed as follows:

These boxes shall be the same as those for No. 3 cans, except that wires shall be stapled to the tops and bottoms with four staples to each wire and to the sides with three staples to each wire.

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[1] Specifications for boxes of other kinds of veneer and with cleats of other species than those listed have been withheld pending tests.

AMERICAN SOCIETY FOR TESTING MATERIALS
PHILADELPHIA, PA., U. S. A.
AFFILIATED WITH THE
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS
FOR
INSULATED WIRE AND CABLE: 30-PER-CENT HEVEA RUBBER.[1]

Serial Designation: D 27 - 16 T.

These specifications are issued under the fixed designation D 27; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916.

1. These specifications cover conductors and rubber insulation only. The design and factor of safety depend upon the service conditions and shall be at the option of the purchaser. **Material Covered.**

(*A*) *Conductor.*

I. MANUFACTURE.

2. The conductor shall be made of soft annealed copper, properly tinned, and have the properties and characteristics herein required. **Material.**

3. Each individual wire of a stranded conductor shall be considered separately and shall be designated as a strand. **Strand.**

4. Each solid conductor and each strand shall be round and reasonably free from imperfections. **Shape.**

5. The stranding shall be concentric, unless otherwise specified, and shall conform to Table I. **Stranding.**

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. E. A. Barrier, Chairman of Committee D-11 on Rubber Products, 31 Milk Street, Boston, Mass.

Density. 6. For the purpose of calculating weights, cross-sections, etc., in conductivity determinations, the density of the copper shall be taken as 8.89. See Appendix I.

TABLE I.—STRANDING.

ASSOCIATION OF RAILWAY ELECTRICAL ENGINEERS.)

Sizes.	Minimum Number of Strands in Conductor.
2 000 000 to 1 600 000 C. M.	127
1 500 000 " 1 100 000 "	91
1 000 000 " 550 000 "	61
500 000 " 250 000 "	37
No. 0000 " No. 1 A. w. g. or B. & S.	19
No. 2 " No. 8 "	7
Smaller sizes	1

II. PHYSICAL PROPERTIES AND TESTS.

Tensile Properties. 7. Each solid conductor or strand shall be so drawn and annealed that after tinning it shall conform to the properties given in Table II.

TABLE II.—TENSILE PROPERTIES.

AMERICAN SOCIETY FOR TESTING MATERIALS.

Diameter, in.	Maximum Tensile Strength, lb. per sq. in.	Minimum Elongation in 10 in., per cent.
0.460 to 0.290 Incl.	36 000	35
0.289 " 0.103. "	37 000	30
0.102 " 0.021. "	38 500	25
0.020 " 0.003. "	40 000	20

Tension Tests. 8. (*a*) *Method of Test.*—Tensile tests shall be made on fair samples and the elongation shall be determined as the permanent increase in length, due to the breaking of the wire in tension, measured between bench marks originally 10 in. apart. The specimen shall break between the bench marks and not closer than 1 in. to either mark.

(*b*) *Number of Tests.*—Samples shall be taken in accordance with Section 16.

(*c*) *Retests and Rejections.*—If upon testing a sample from a coil, reel or spool of wire, the results are found to be above the stated value for tensile strength or below the stated value for elongation, tests upon two additional samples will be made and the average of the three tests shall determine acceptance or rejection.

Conductivity.

9. The conductivity of the copper shall be not less than 98 per cent of the annealed copper standard. See Appendix I.

Tinning Tests.

10. (*a*) *Test.*—Each sample before stranding or insulating shall be given the following tests at the factory: The sample shall be thoroughly cleaned by immersing in redistilled petroleum ether, followed by immersion in 95-per-cent alcohol. The sample shall then be immersed in hydrochloric acid (sp. gr. 1.088) at a temperature of from 60 to 70° F. (15°.55–21°.10 C.) for one minute, washed in distilled water (the surplus water shaken off) and immersed in a solution of sodium sulfide for 30 seconds and again washed in water (the surplus water shaken off). The above operation shall be repeated four times for samples 0.02 in. in diameter or over, and three times for samples less than 0.02 in. in diameter. After the completion of the required number of cycles the samples shall not show any sign of blackening in the air which is perceptible to the eye.

(*b*) *Strength of Solution.*—The solution of sodium sulfide shall have sufficient strength to thoroughly blacken in 5 seconds a piece of untinned copper wire that has previously been cleaned in 95 per cent alcohol. The solution shall be prepared by thoroughly saturating (by boiling) a solution of sodium monosulfide with sulfur and shall have a specific gravity of 1.142 at 60° F. (15°.55 C.).

(*c*) *Number of Tests.*—Samples shall be taken in accordance with Section 16.

(*d*) *Retests and Rejections.*—If the specimen tested in accordance with Section 10 (*a*) shows any signs of blackening, two more specimens shall be tested. If one of these two additional specimens shows any signs of blackening, that coil or reel shall be rejected. If both specimens are free from any signs of blackening, the coil or reel shall be accepted. If more than

10 per cent of the samples in the entire order fail, all of the wire shall be rejected. If 10 per cent or less of the samples in the entire lot fail, each coil, reel or length may be tested and accepted or rejected upon the results of the individual tests.

III. PERMISSIBLE VARIATIONS IN DIMENSIONS.

Diameter and Area.

11. (*a*) *Permissible Variation.*—When the diameter of solid conductors and strands is specified, the permissible variation from the specified value shall not exceed 1 per cent under or 2 per cent over for wire 0.02 in. in diameter and larger, and 0.1 mil under for wire less than 0.02 in. in diameter.

When the area of cross-section is specified, the permissible variation shall not exceed 2 per cent under the specified value.

(*b*) *Method of Gaging Diameter.*—When wire is submitted in coils, each coil shall be gaged in three places, one near each end and one approximately at the middle. When wire is submitted on spools or reels, approximately 12 ft. of the wire shall be reeled off and the wire then gaged in six places between the second foot and the twelfth foot from the end.

(*c*) *Calculation of Area.*—The area of cross-section of wire shall be calculated from the average of the measurements of the diameter made in accordance with Section (*b*). The area of cross-section of cable shall be considered to be the sum of the cross-sectional areas of its component wires, when laid out straight and measured perpendicular to their axes.

(*d*) *Rejection.*—A coil or reel shall be rejected if the average diameter obtained from the measurements made in accordance with paragraph (*b*), or the area as calculated in accordance with paragraph (*c*), is not within the limits specified in paragraph (*a*).

A coil or reel shall be rejected if any individual measurement of diameter or of area of cross-section is not within twice the limits specified in paragraph (*a*).

(*B*) *Insulation.*

IV. CHEMICAL PROPERTIES AND TESTS.

Composition of Compound.

12. (*a*) *Composition.*—The insulation shall contain exclusively Hevea rubber which has not been previously used, waxy hydrocarbons consisting of ceresin or refined paraffin, sufficient

sulfur to properly vulcanize, and fillers which are entirely inorganic mineral matter containing no red lead, carbon or bitumen.

(*b*) *Requirements.*—The vulcanized compound shall conform on analysis to the following requirements expressed as percentages, by weight, of the whole sample:

	MAXIMUM.	MINIMUM.
Rubber	33	30
Waxy hydrocarbons	4	..
Free sulfur	0.7	..

Results shall be taken between the limits given in proportion to the percentage by weight of the rubber found.

The limits allowed for 30-per-cent rubber compound shall be as follows:

	MAXIMUM.	MINIMUM.
Saponifiable acetone extract	1.35	0.55
Unsaponifiable resins	0.45	....
Chloroform extract	0.90	....
Alcoholic potash extract	0.55	....
Total sulfur (see note)	2.10	....
Specific gravity	....	1.75

The limits allowed for 33-per-cent rubber compound shall be as follows:

	MAXIMUM.	MINIMUM.
Saponifiable acetone extract	1.50	0.60
Unsaponifiable resins	0.50	....
Chloroform extract	1.00	....
Alcoholic potash extract	0.60	....
Total sulfur (see note)	2.30	....
Specific gravity	....	1.67

The acetone solution shall not fluoresce.

The acetone extract (60 cc.) shall not be darker than a light straw color.

Hydrocarbons shall be solid, waxy and not darker than a light brown.

Chloroform extract (60 cc.) shall not be darker than a straw color.

Contamination of the compound, such as by the use of impregnated tapes, will not excuse the manufacturer from conforming to this specification.

NOTE.—The limit on total sulfur may be omitted at the option of the purchaser.

The compound shall be analyzed by the procedure recommended by the Joint Rubber Insulation Committee. See Appendix II.

(c) *Samples.*—Samples for chemical analysis shall be taken before the application of the braid and after the material has passed all physical and electrical tests. The purchaser may take samples in accordance with Section 16. The purchaser shall assure himself that all samples are free from contamination and change due to torch heating. Wherever practicable, samples shall be taken at a distance of at least 3 ft. from the end of the wire.

(d) *Retests and Rejections.*—The purchaser may make a chemical analysis on any one of the samples selected as above to determine if the compound meets the requirements of Section 12 (*b*). Failure of any one sample selected shall be sufficient cause to reject the wire which the sample represents, except in the case of failure to meet the requirements of either or both free sulfur and chloroform extract in accordance with Section 12 (*b*). In case of such failure the coil from which the sample was taken shall be rejected and two additional samples taken from the remainder of the order. The remainder of the order shall be accepted if both samples so selected shall meet the requirements for free sulfur or chloroform extract in accordance with Section 12 (*b*). The entire order shall be rejected if either sample fails to meet the requirements.

V. PHYSICAL PROPERTIES AND TESTS.

Physical Properties.

13. The test specimen shall have the following physical properties.

Tensile strength, minimum, lb. per sq. in.	1000
Set, maximum in 2 in., in.	$\frac{3}{8}$
Elongation, minimum before rupture, in.	2 to 9

Physical Tests.

14. (*a*) *Tension Test.*—A test specimen having a length of not less than 2 in., marked with bench marks 2 in. apart, shall be placed in the jaws of a test machine (maximum distance

between jaws holding the test specimen, 4 in.) and stretched at the rate of 20 in. per minute (jaw speed) until the specimen breaks. The test specimen shall break between the bench marks and the tensile strength shall be calculated upon the area of the original sample.

(*b*) *Set Test.*—A second test specimen having a length of not less than 6 in., marked with bench marks 2 in. apart, shall be placed in the jaws of a test machine (maximum distance between jaws holding test specimen, 4 in.) and stretched at a rate of 20 in. per minute until the bench marks are 6 in. apart. After the termination of this stretch, the test specimen shall be released within 5 seconds and the set determined 1 minute after the beginning of release.

(*c*) *Elongation Test.*—After the determination of the set in accordance with paragraph (*b*), the *same* specimen shall be placed in the jaws of a test machine (maximum distance between jaws holding test specimen, 4 in.) and stretched at the rate of 20 in. per minute (jaw speed) until the specimen breaks. The test specimen shall break between the bench marks.

(*d*) *Accuracy of Machine.*—The test machine shall be accurate within 1 per cent of the breaking load.

(*e*) *Jaws.*—The jaws of the machine shall be of an approved type.

(*f*) *Temperature.*—All physical tests shall be made at a room temperature of from 65 to 85° F. (18°.33 to 29°.44 C.) inclusive, and the test specimen shall have been kept at the room temperature not less than 30 minutes prior to the tests.

Test Specimen.

15. (*a*) *Test Specimen.*—The test specimen may be the entire section of the insulation in the case of small wires, or in the case of a large wire, a segment of a section, cut with a sharp knife held tangentially to the conductor. The test specimen shall be as free as possible from surface incisions and imperfections.

(*b*) *Buffing.*—In event of any irregularities on the surface of the test specimen, it shall be made smooth and of uniform thickness within 5 per cent of the original thickness by buffing, except when large strands are used, in which case the rubber sample shall be buffed sufficiently to remove all corrugations.

(*c*) *Limits.*—There shall be no limit to the cross-section of the test specimen, except as restricted by the capacity of the test machine.

(*d*) *Calculation of Area.*—Calculation of the area of test specimen shall be made as follows:

(1) When the total cross-section of the insulation is used, the area shall be calculated as the area of the circle whose diameter is the minimum average outside diameter of the insulation minus the area of the conductor. The area of a stranded conductor shall be figured from its maximum diameter.

(2) When a slice cut from the wire by a knife held tangent to the wire is used, and the slice so cut has the cross-section of a segment of a circle, the area shall be calculated as that of the segment of a circle whose diameter is that of the insulation. The height of the segment is the wall of insulation on the side from which the slice is taken. (The values are most easily obtained from a table giving the areas of segments of a unit circle for the ratio of the height of the segment to the diameter of the circle.)

(3) When the cross-section of the slice is not a segment of a circle, the area shall be calculated from a direct measurement of the volume or from the specific gravity and the weight of a known length of a uniform cross-section.

(4) When a portion of a sector of a circle has to be taken (as in the case of large conductors with thin walls) the area shall be calculated as the thickness times the width. (This applies either to a straight test piece or one stamped out with a die, and assumes that corrugations have been removed by buffing.)

(5) When a portion of a sector of a circle has to be taken on large conductors with thick walls the area shall be calculated as the proportional part of the area of the total cross-section.

Number of Physical Test Specimens.

16. (*a*) *Less than 500 Feet.*—When an order calls for less than 500 ft., physical tests shall be waived.

(*b*) *Over 500 Feet.*—When an order calls for 500 ft. or more and is made into one or more coils, reels or lengths, samples shall be taken from 10 per cent of the coils, reels or lengths, but in all cases there shall be one sample taken.

Retests and Rejections, Physical Tests

17. (*a*) *Retests.*—If a specimen fails to pass in either of the three tests prescribed in Section 14, two more specimens shall be taken from the same sample and the average of the results shall determine whether or not the sample complies with the requirements.

(*b*) *Rejections.*—When ten or more samples are selected in any inspection lot, all coils, reels or lengths shall be rejected if more than 10 per cent of the samples fail. If 10 per cent or less fail, each coil, reel or length may be tested and shall be accepted or rejected upon the result of individual test. Where the number of samples selected in any inspection lot is less than ten, all coils, reels or lengths shall be rejected if more than 20 per cent of the samples fail. If 20 per cent or less fail, each coil, reel or length may be tested and shall be accepted or rejected upon the result of individual test.

TABLE III.—VALUES OF TEST POTENTIALS, IN KILOVOLTS.

(ASSOCIATION OF RAILWAY ELECTRICAL ENGINEERS.)

Size of Conductors.	Thickness of Insulation, 64ths in.							
	2	3	4	5	6	7	8	10
18 A. w. g. or B. & S.	1.0	2.5	4.5	5.5	6.5	7.5	8.5	10.5
16 “ “	1.0	2.5	4.5	5.5	6.5	7.5	8.5	10.5
14 “ “	...	2.5	5.0	6.0	7.0	8.0	9.0	11.0
12 “ “	...	2.5	5.0	6.0	7.5	8.5	9.5	11.5
10 “ “	...	3.0	5.0	6.5	8.0	8.5	10.0	12.0
8 “ “	...	3.0	5.0	7.0	8.0	9.5	11.0	13.0
6 “ “	...	...	5.0	6.5	8.5	10.0	11.5	14.0
4 “ “	...	...	4.5	6.5	8.5	10.0	11.5	14.5
2 “ “	...	...	4.0	6.0	8.0	10.0	12.0	15.0
0 “ “	...	...	...	5.5	8.0	10.0	12.0	15.5
00 “ “	...	...	...	5.0	7.5	9.5	11.5	15.5
000 “ “	...	...	...	5.0	7.5	9.5	11.5	15.5
0000 “ “	...	...	...	4.5	7.0	9.0	11.5	15.5
250 000 C. M.	...	...	...	4.0	6.5	9.0	11.0	15.5
500 000 “	...	...	...	2.5	5.0	7.5	10.0	14.5
750 000 “	...	...	...	...	...	6.5	9.0	14.0
1 000 000 “	...	...	...	...	...	5.5	8.0	13.0
1 250 000 “	...	...	...	...	...	...	7.5	12.5
1 500 000 “	...	...	...	...	...	...	7.0	12.0
1 750 000 “	...	...	...	...	...	...	6.5	11.5
2 000 000 “	...	...	...	...	...	...	5.0	10.5

VI. ELECTRICAL PROPERTIES AND TESTS.

Electrical Properties

18. (*a*) *Place.*—All electrical tests shall be made at the factory.

(*b*) *Requirements.*—Every coil, reel or length of wire, after vulcanization and before the application of paraffin or

TABLE IV.—INSULATION RESISTANCE, IN MEGOHM-MILES AT 60° F.[1]

(ASSOCIATION OF RAILWAY ELECTRICAL ENGINEERS.)

Size of Conductors.	Thickness of Insulation, 64ths in.																
	2	3	4	5	6	7	8	10	12	14	16	18	20	22	24	26	28
18 A. w. g. or B. & S.	1600	2050	2450	2800	3000	3200	3400	3750	4050	4300	4500	4700	4900	5000	5150	5300	5400
16 " "	1400	1800	2150	2400	2650	2850	3050	3400	3650	3950	4150	4350	4500	4650	4800	4900	5050
14 " "	....	1530	1850	2150	2350	2550	2650	3050	3350	3550	3800	3950	4100	4300	4400	4550	4650
12 " "	....	1350	1600	1850	2050	2250	2400	2750	3000	3250	3400	3600	3750	3900	4050	4150	4300
10 " "	....	1150	1350	1600	1800	2000	2150	2400	2650	2900	3100	3250	3400	3550	3700	3800	3900
8 " "	....	850	1050	1250	1450	1650	1750	2050	2200	2400	2600	2750	2900	3050	3150	3250	3350
6 " "	....	....	850	1050	1200	1350	1450	1750	1950	2100	2300	2450	2550	2700	2800	2900	3000
4 " "	....	....	750	850	1000	1150	1250	1450	1650	1850	2000	2150	2250	2400	2500	2600	2700
2 " "	....	....	650	750	850	950	1050	1250	1450	1600	1700	1850	1950	2100	2200	2300	2400
1 " "	....	....	600	650	750	850	1000	1150	1350	1450	1600	1750	1850	1950	2050	2150	2250
0 " "	....	....	....	600	700	800	950	1050	1200	1350	1500	1600	1700	1800	1900	2000	....
00 " "	....	....	....	550	650	750	850	950	1050	1250	1350	1500	1600	1700	1800	....	....
000 " "	....	....	....	500	600	650	750	850	1000	1150	1250	1350	1450	1550	....	....	....
0000 " "	....	....	....	450	550	600	650	800	950	1050	1150	1250	1350	1450	....	....	....
250 000 C. M.	....	....	....	400	475	575	625	725	875	1000	1100	1200	1275	....	....	....	....
350 000 "	....	....	....	350	425	475	525	675	775	850	950	1050	1125	....	....	....	....
500 000 "	....	....	....	300	375	400	475	575	675	750	850	900	....	....	....	....	....
750 000 "	....	....	....	....	....	325	400	475	525	625	700	775	....	....	....	....	....
1 000 000 "	....	....	....	....	....	300	325	400	475	550	625	....	....	....	....	....	....
1 250 000 "	....	....	....	....	....	....	325	375	425	500	575	....	....	....	....	....	....
1 500 000 "	....	....	....	....	....	....	300	325	400	475	....	....	....	....	....	....	....
1 750 000 "	....	....	....	....	....	....	275	300	375	450	....	....	....	....	....	....	....
2 000 000 "	....	....	....	....	....	....	200	275	325	425	....	....	....	....	....	....	....

NOTE.—For intermediate sizes, use values of next larger size.

[1] This table is based on the constant 4000 in the following formula:

$R = K \log \frac{D}{d}$, where R = resistance in megohms, K = Constant, D = diameter over insulation, d = diameter over conductor.

any covering other than tape or braid used in vulcanization, shall successfully withstand a high voltage test as specified in Table III, and shall have an insulation resistance not less than that specified in Table IV. These tests shall be made after not less than 18 hours immersion in water, and while still immersed.

High Voltage Test.

19. The test voltage shall be applied for 5 minutes. The test shall be made in accordance with the Standardization Rules of the American Institute of Electrical Engineers. See Appendix I.

TABLE V.

(TESTS SHALL BE MADE AT TEMPERATURES WITHIN THE SCOPE OF THIS TABLE.)

Temperature.		Coefficient.	Temperature.		Coefficient.
Deg. Fahr.	Deg. Cent.		Deg. Fahr.	Deg. Cent.	
46	7.8	0.694	61	16.1	1.026
47	8.3	0.709	62	16.7	1.053
48	8.9	0.729	63	17.2	1.081
49	9.4	0.746	64	17.8	1.109
50	10.0	0.769	65	18.3	1.138
51	10.6	0.787	66	18.9	1.169
52	11.1	0.806	67	19.4	1.200
53	11.7	0.833	68	20.0	1.231
54	12.2	0.854	69	20.6	1.264
55	12.8	0.877	70	21.1	1.297
56	13.3	0.900	71	21.7	1.331
57	13.9	0.917	72	22.2	1.366
58	14.4	0.943	73	22.8	1.402
59	15.0	0.970	74	23.3	1.438
60	15.6	1.000	75	23.9	1.477

Insulation Resistance.

20. (*a*) *Method.*—This test shall be made in accordance with the Standardization Rules of the American Institute of Electrical Engineers. See Appendix I.

(*b*) *Temperature Coefficient.*—The insulation resistance (megohms) shall be reduced to that at 60° F. (15°.55 C.) by multiplying by the coefficient in Table V corresponding to the temperature at which test is made.

Rejections. Electrical Test.

21. Every coil, reel or length shall be rejected if it fails to comply with the electrical requirements herein specified.

(*C*) *Inspection.*

Inspection.

22. (*a*) The manufacturer shall notify the purchaser sufficiently in advance of the completion of the wire or cable to permit of arrangement for the inspection.

(*b*) The inspector representing the purchaser shall have free entry at all times, while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the wire ordered, except compounding room. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the wire is being furnished in accordance with these specifications. Tests and inspection shall be made prior to shipment, at the place of manufacture.

(*c*) The purchaser may make the tests to govern the acceptance or rejection of the wire in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

Rehearing. 23. Samples of rejected material shall be preserved for two weeks from date of test report. In case of dissatisfaction with the results of test, the manufacturer may make claim for a rehearing within that time. Sealed duplicate samples may be retained by the manufacturer at his option.

APPENDIX I.

EXTRACTS FROM STANDARDIZATION RULES OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

(Edition July 1, 1915.)

CONDUCTIVITY OF COPPER.

1. The following shall be taken as normal values for standard annealed copper:

(*a*) At a temperature of 20° C. the resistance of a wire of standard annealed copper 1 m. in length and of a uniform section of 1 sq. mm. is 1/58 ohm = 0.017241 ohm.

(*b*) At a temperature of 20° C. the density of standard annealed copper is 8.89 g. per cubic centimeter.

(*c*) At a temperature of 20° C. the "constant mass" temperature coefficient of resistance of standard annealed copper, measured between two potential points rigidly fixed to the wire, is 0.00393 = 1/254.45 . . . per degree Centigrade.

(*d*) As a consequence, it follows from (*a*) and (*b*) that at a temperature of 20° C. the resistance of a wire of standard annealed copper of uniform section, 1 m. in length and weighing 1 g. is $(\frac{1}{58}) \times 8.89 = 0.15328$ ohm.

HIGH VOLTAGE TEST.

(*a*) *Frequency.*

2. The frequency of the test voltage shall not exceed 100 cycles per second, and should approximate as closely as possible to a sine wave. The source of energy should be of ample capacity.

(*b*) *Rate of Increase of Voltage.*

3. The initially-applied voltage shall not be greater than the working voltage and the rate of increase shall not be over 100 per cent in 10 seconds.

INSULATION RESISTANCE TEST.

4. The apparent insulation resistance should be measured after the dielectric-strength test, measuring the leakage current after a one-minute electrification, with a continuous e.m.f. of from 100 to 500 volts, the conductor being maintained positive to the water.

APPENDIX II.

JOINT RUBBER INSULATION COMMITTEE PROCEDURE FOR THE ANALYSIS OF RUBBER COMPOUND.

OBJECT OF THE ANALYSIS.

1. The object of this procedure of analysis is to determine whether rubber compounds comply chemically with the accompanying specification which is intended to secure compounds containing 30 per cent of the best Hevea rubber, and mineral fillers.

OUTLINE OF PROCEDURE.

2. The general procedure is shown in Fig. 1.

GENERAL.

3. Make the analysis upon the insulation after vulcanization and, whenever possible, before the saturation of the braid. Wipe the insulation thoroughly with a damp cloth to remove any adhering material, but do not remove waxy hydrocarbons from the surface.

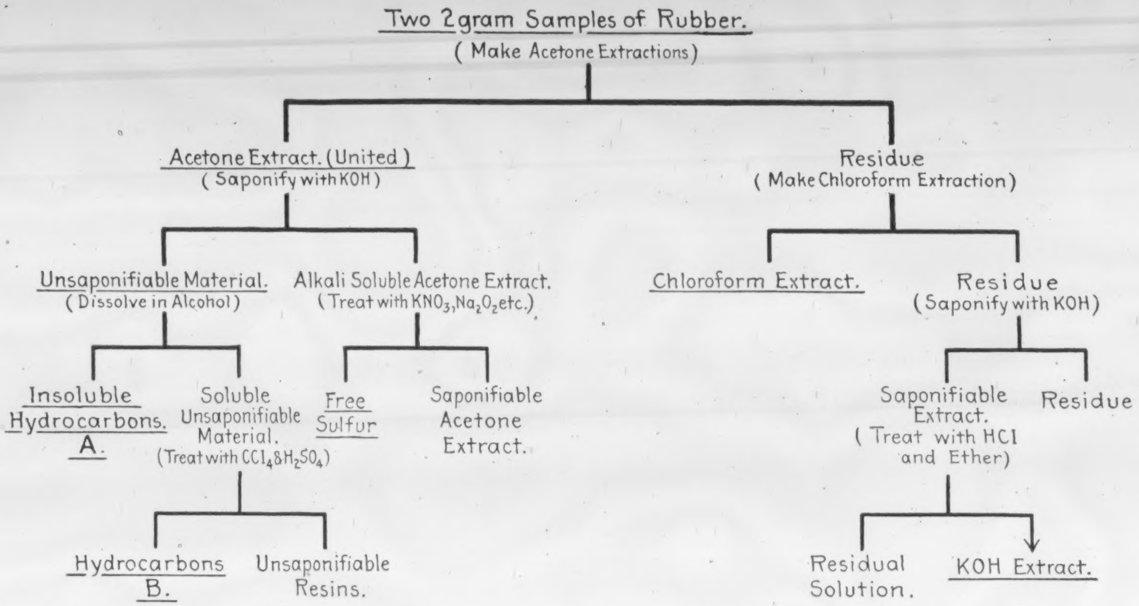
4. If, however, a saturated braided sample must be used, remove the braid and sandpaper the insulation to a depth of at least 0.005 in. and wipe with a damp cloth. In such cases report the condition of the sample.

5. Perform all determinations in duplicate and take the average value arbitrarily as the true value. Duplicate determinations must check within the limits specified.

6. Make blanks on all determinations and deduct the results accordingly.

SAMPLE.

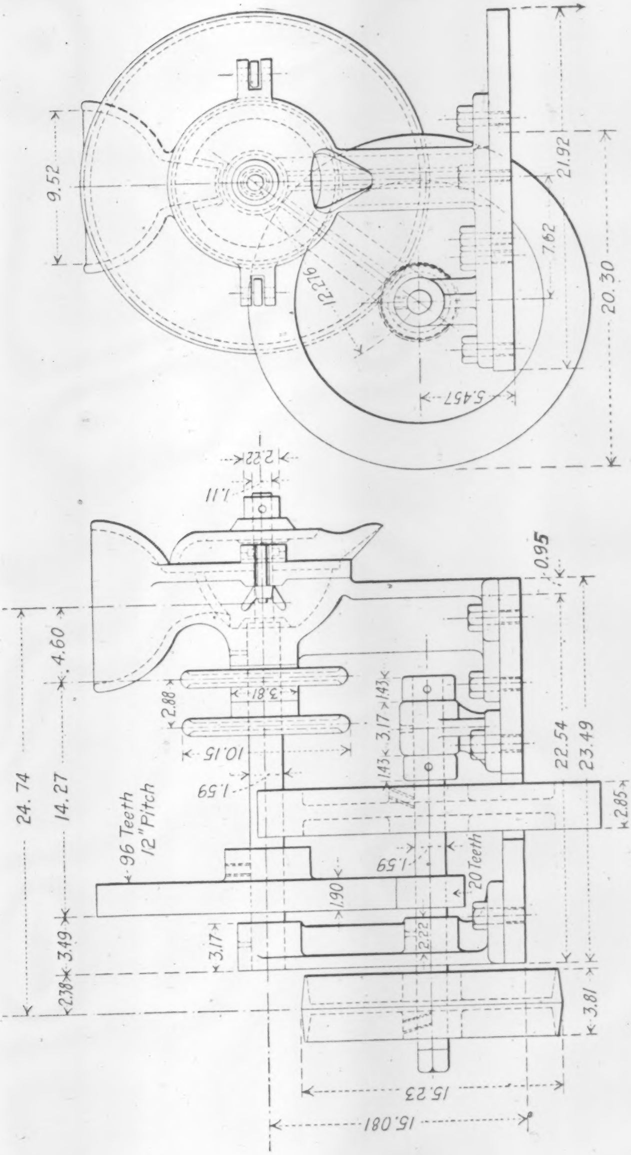
7. Remove the insulation entirely from sufficient wire to give a sample weighing about 25 g. Cut this into small strips and grind slowly in either a No. 0 Enterprise coffee mill or a


Two 2gram Samples of Rubber.
(Make Acetone Extractions)
Acetone Extract. (United)
(Saponify with KOH)
Residue
(Make Chloroform Extraction)
Unsaponifiable Material.
(Dissolve in Alcohol)
Alkali Soluble Acetone Extract.
(Treat with KNO_3, Na_2O_2 etc.)
Chloroform Extract.
Residue
(Saponify with KOH)
Insoluble Hydrocarbons. A.
Soluble Unsaponifiable Material.
(Treat with CCl_4 & H_2SO_4)
Free Sulfur
Saponifiable Acetone Extract.
Saponifiable Extract.
(Treat with HCl and Ether)
Residue
Hydrocarbons B.
Unsaponifiable Resins.
Residual Solution.
KOH Extract.

Total Waxy Hydrocarbons = A + B.

Weigh Substances with Names Underlined; Other Substances by Difference.

FIG. 1.—Outline of Method For Rubber Analysis.
(Exclusive of Fillers and Total Sulfur Determinations.)

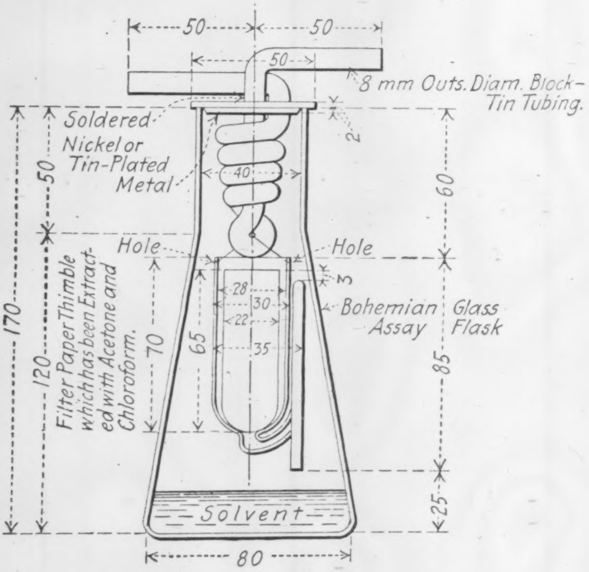

9.52
21.92
7.62
20.30
12.216
5.457
2.22
1.11
0.95
24.74
4.60
14.27
2.88
3.81
10.15
1.59
1.43
3.17
1.43
22.54
23.49
2.85
96 Teeth
12" Pitch
1.90
1.59
20 Teeth
3.49
2.38
3.17
2.22
3.81
15.23
15.081

Grinding Plates of the No. 0 Enterprise Coffee Mill to be Used.

(All Dimensions in Centimeters.)

FIG. 2.—Rubber Grinder.

mill such as shown by Fig. 2. Adjust the grinder so that not more than 20 per cent will pass through a 40-mesh sieve. Sift all the material through a 20-mesh sieve, regrinding what is retained on the sieve until the entire sample has passed through. The wires of the sieves shall be evenly spaced in both directions and shall be of 0.016 and 0.010 in. diameter in the 20 and 40-mesh sieves respectively. Remove with a strong magnet any metal that may have come from the grinder and thoroughly mix the sample.


50
50
50
8 mm Outs. Diam. Block-Tin Tubing.
Soldered
Nickel or Tin-Plated Metal
2
40
50
60
170
120
Hole
Hole
3
28
30
22
35
Filter Paper Thimble which has been Extracted with Acetone and Chloroform.
70
65
Bohemian Assay
Glass Flask
85
25
Solvent
80

(All dimensions in millimeters.)

FIG. 3.—Extraction Apparatus.

EXTRACTION APPARATUS.

8. The extraction apparatus shall conform to Fig. 3. It shall be heated so that the period of filling an empty syphon cup with acetone and completely emptying it, will be between 2½ and 3½ minutes.

PREPARATION OF REAGENTS.

Acetone. 9. Acetone shall be freshly distilled over anhydrous K_2CO_3, using the fraction 56–57° C.

10. Alcoholic KOH solution shall be of normal strength and shall be made freshly by dissolving the proper amount of KOH (purified by alcohol) in 95 per cent alcohol which has previously been distilled over KOH. The solution shall be allowed to stand for 24 hours and only the clear liquid used. **KOH.**

11. Ether shall be washed with three successive portions of distilled water and distilled, using the fraction 34–36° C. **Ether.**

12. Chloroform shall be pure and freshly distilled. **Chloroform.**

13. Carbon tetrachloride shall be pure and freshly distilled. **Carbon Tetrachloride.**

14. Reagents not otherwise specified shall be c.p. Water shall be distilled.

ACETONE EXTRACT.

15. Extract continuously with 60 cc. of acetone for 8 hours, two 2-g. samples that have been prepared within 24 hours. Unite the extracts in a weighed flask, using hot chloroform to rinse the flasks. Distill off the reagents and dry the flask and contents for 4 hours at 95–100° C. Desiccate until cool and weigh. Continue to dry for 2-hour periods until constant weight is obtained. In drying, place the flask on its side but at a sufficient angle from the horizontal so that the extract does not appreciably run down the side of the flask. **Acetone Extract.**

UNSAPONIFIABLE MATERIAL.

16. Add to the acetone extract 50 cc. of alcoholic KOH solution, boil under a reflux condenser for 2 hours, and evaporate to dryness, removing all alcohol. Add 10 cc. of water and 20 cc. of ether; heat until the wax, etc., are in solution, cool, transfer to a separatory funnel, wash out the flask with warm water and then cool, finally with two 20-cc. portions of ether. The water volume should be 100 cc. and the ether at least 40 cc. Shake vigorously for 2 minutes, and allow the solutions to separate thoroughly. Draw off the aqueous solution into a second funnel, leaving in the first funnel the ethereal solution and any flocculent material that may be present. Again rinse the flask with 20 cc. of ether and add it to the aqueous solution; shake vigorously for 2 minutes, and when separated draw off the aqueous solution and unite in the first funnel the ethereal solutions and any flocculent material. Repeat, shaking with 20-cc. **Unsaponifiable Matter.**

portions of ether until the extraction is complete, using at least 120 cc. of ether. Wash the flask and the funnel, from which the ethereal solution has been taken, with water, until they are free from alkali, subsequently using this wash water to wash the ethereal solution. Continue washing with water until it has been washed twice after it shows no alkaline reaction. Retain with the ethereal solution any flocculent material. Filter the ethereal solution from the flocculent material, through a small pellet of extracted cotton, into a weighed flask, washing first with ether and subsequently with hot chloroform, using this to rinse the original flask and both separatory funnels. Evaporate the solvents and dry the extract to constant weight at 95 to 100° C.; desiccate until cool and weight.

HYDROCARBONS A.

Hydrocarbons A.

17. Add 50 cc. absolute alcohol to the unsaponifiable material and warm until solution is as complete as possible. Cool the solution to −4 or −5° C. and maintain at this temperature for 1 hour by packing the flask in a mixture of ice and salt. Filter out the waxy hydrocarbons, using a funnel packed with ice and salt, and apply suction if necessary. Wash the flask and filter with about 25 cc. of 95 per cent alcohol, which has been previously cooled in the same temperature. Catch the filtrate in a flask which is afterwards cooled to −4 or −5° C. to make sure that all possible waxy hydrocarbons have been removed, and refilter if necessary. Dissolve the residue on the filter paper with hot chloroform, into the original flask. Evaporate the chloroform and dry the flask to constant weight at 95 to 100° C. Cool in a desiccator and weigh.

HYDROCARBONS B.

Hydrocarbons B.

18. Evaporate the alcohol from the flask containing the alcoholic soluble unsaponifiable material, add 25 cc. carbon tetrachloride and transfer to a separatory funnel. Shake with concentrated H_2SO_4, drain off the discolored acid and repeat with fresh portions of acid until there is no longer any discoloration. After drawing off all the acid, wash the carbon tetrachloride solution with repeated portions of water until all traces of acid

are removed. Transfer the carbon tetrachloride solution to a weighed flask; evaporate off the solvent and dry the flask to constant weight at 95 to 100° C. Cool in a desiccator and weigh.

FREE SULFUR.

Free Sulfur.

19. Add 2 g. KNO_3 to the aqueous solution and washings from the ethereal separation of the unsaponified material. Evaporate to dryness in a silver or nickel dish and heat to quiet fusion, avoiding contamination with sulfur fumes. Transfer with water to an evaporating dish, acidify with HCl, evaporate to dryness, and dehydrate silica. Add 2 cc. concentrated HCl, take up in water, filter and wash, making a volume of 200 cc. Heat to boiling and add slowly a slight excess of hot 10 per cent $BaCl_2$ solution. Allow to stand over night, filter, wash, ignite, weigh the $BaSO_4$ and calculate the sulfur.

DEFINITION OF TERMS DESCRIBING COMPONENTS OF ACETONE EXTRACT.

Organic Extract.

20. The difference between the Acetone Extract and the Free Sulfur shall be called the Organic Extract.

Saponifiable Acetone Extract.

21. The difference between the Organic Extract and the Unsaponifiable Material shall be called the Saponifiable Acetone Extract.

Waxy Hydrocarbon.

22. The sum of the Hydrocarbons A and B shall be called the total Waxy Hydrocarbons.

Unsaponifiable Resins.

23. The difference between the Unsaponifiable Material and the Waxy Hydrocarbons shall be called Unsaponifiable Resins.

CHLOROFORM EXTRACT.

Chloroform Extract.

24. Extract continuously the residues from both of the acetone extractions (without necessarily removing the acetone that may be on them) for 4 hours with 60 cc. of chloroform, unite the extractions in a weighed flask, using hot chloroform to rinse the flasks. Distill off the solvent and dry the flask and contents for 2 hours at 95 to 100° C. Desiccate until cool and weigh. Continue to dry for 1-hour periods until constant weight is obtained. In drying, place the flask on its side but at a sufficient angle from the horizontal so that the extract does

not appreciably run down the side of the flask. (If it is needful to wait after the acetone extraction, before starting the chloroform extraction, the sample must be kept in a vacuum of at least 50 mm. of mercury.)

ALCOHOLIC-POTASH EXTRACT.

Alcoholic KOH Extract.

25. Dry the residue from the chloroform extraction at 50 to 60° C. until odor of chloroform can no longer be detected, unite residues from the two 2-g. samples in a 200-cc. Erlenmeyer flask. Add 100 cc. alcoholic KOH solution and boil for 4 hours under a reflux condenser. Filter the solution by decantation through an 11-cc. hardened filter paper into a beaker and wash twice, using each time 25 cc. hot absolute alcohol and then wash thoroughly with hot water. Wash any rubber on the filter paper back into the original flask and reserve this for the determination of the rubber hydrocarbons. Evaporate the solution to approximate dryness, take up in warm water and transfer to a separatory funnel. Acidify with 15 cc. of 5 normal HCl, using this to rinse the beaker. Add sufficient water to make the bulk of the solution 100 cc. When cool add 40 cc. of ether, using it to rinse the beaker in 20-cc. portions. Shake the aqueous and ethereal solutions thoroughly. After complete separation, draw off the aqueous solution and treat in another separatory funnel, with a fresh 20-cc. portion of ether. Continue to shake the aqueous solution with fresh portions of ether until a colorless portion has been obtained, then shake out twice more. Unite the ethereal solutions and wash with successive additions of water, continuing twice after the water shows no acid reaction. Filter through a plug of extracted cotton into a tared flask, wash the filter and funnel with ether, evaporate the ether without boiling and dry the residue to constant weight at 95 to 100° C. Cool in a desiccator and weigh.

RUBBER HYDROCARBONS.

Rubber Hydrocarbons.

26. Add to the flask containing the rubber residue from the alcoholic KOH extraction, sufficient water to make the total volume of the solution 125 cc. and then add 25 cc. concentrated HCl. Heat for an hour at 97 to 100° C. Decant the supernatant liquid through a hardened filter paper on a Buch-

ner funnel 7 cm. diameter, using suction; wash the residue with 25 cc. hot water and decant. (While a Buchner funnel is recommended, it is permissible to use an 11-cm. hardened filter paper with platinum cone, in a 60-deg. funnel.) Perform this entire treatment with water and HCl three times and save the first and second decantations for the "organic matter" test described in Section 33. The rubber at this stage should be white and practically free from black specks of undissolved fillers; if not, continue the acid treatment until the black specks disappear. (If carbon is present, all the particles of rubber will be grayish, bluish, or black, depending on the form and quantity of carbon used. Black specks in light particles of rubber usually indicate the presence of lead sulfide which must be removed to prevent the formation of lead sulfate on igniting the residue *C*.) Add 150 cc. of hot water to the flask and let stand on a steam bath or hot plate for half an hour and decant through the filter paper, repeating until washings are free from chlorides. (See Section 33.) Transfer all the rubber in the flask to the filter paper and dry as much as possible by suction. Wash the rubber with 50 cc. of 95-per-cent alcohol, using suction. Transfer the entire residue to a weighing bottle. Dry at 95 to 100° C. for an hour, cool in a vacuum desiccator under reduced pressure and weigh. Dry for a half hour, cool and weigh, repeating this process until either constant weight is reached or the weight starts to increase. Let this weight be represented by *C*. Determine the ash (*E*) on a portion (*D*) of this residue (*C*) and sulfur (*H*) on the remaining portion (*G*). Also determine the sulfur (*F*) on the ash (*E*). Perform the ash determination as described under ash in Rubber Residue and the sulfur determinations as described under Total Sulfur. Then,

$$\text{Rubber hydrocarbons} = 100\,\frac{C}{4}\left(1-\frac{H}{C}-\frac{E-F}{D}\right)$$

expressed as a percentage of the total sample.

ASH IN RUBBER RESIDUE.

Ash in Rubber Residue.

27. Place about 0.5 g. (*D*) of residue *C* into a weighed porcelain crucible and heat gently, gradually driving off the

volatile matter. When the crucible has ceased to smoke, raise the temperature gradually to between 450 and 500° C., until all organic matter has been burned away, which is usually indicated by the ash becoming white. (an electric muffle furnace with pyrometer is recommended for this purpose.) Cool in a desiccator and weigh, the weight of ash being represented by *E* in the formula for rubber hydrocarbons. Make sulfur test on ash by the method described under Total Sulfur. If, however, the ash (*E*) is not over 0.08 *D*, the determination of sulfur in the ash may be omitted, and *F* assumed to be zero.

TOTAL SULFUR.

Total Sulfur.

28. Mix a 0.5-g. sample with 4 g. of Na_2O_2 and 6 g. of K_2CO_3 in a dry 15-cc. iron crucible. Cover and heat gradually until the mixture fuses, proceeding cautiously, as rapid heating will cause an explosion, and then bring to quiet fusion for 15 to 20 minutes. Apply the heat so as to avoid contamination with sulfur fumes. Rotate the crucible while the melt solidifies. When cool, put crucible and cover into a casserole containing 200 cc. of water; add 5 to 10 cc. of bromine water and boil until the melt is dissolved. Allow the precipitate to settle, decant the liquid through a thick filter and wash the residue with hot water. Acidify the filtrate with HCl, evaporate to dryness and dehydrate silica; add 2 cc. of concentrated HCl, take up in water, filter and wash, making the total volume about 100 cc. Heat to boiling and add slowly a slight excess of hot 10-per-cent $BaCl_2$ solution. Allow to stand over night, filter, wash, ignite, weigh the $BaSO_4$ and calculate to sulfur.

SPECIFIC GRAVITY.

Specific Gravity.

29. The specific gravity shall be the ratio of the weight of a given volume of the rubber to the weight of an equal volume of water, both at 20° C. Cut strips of the largest applicable size from the conductor and use about 5 g. for the sample. Determine the specific gravity in the usual manner by means of a specific gravity bottle. Care must be taken that no air bubbles adhere to the sample.

CHECKS.

30. Specific gravity determinations shall check within 0.01. The other duplicate determinations shall check within the following limits expressed as percentages of the original sample. **Checks.**

DETERMINATION.	CHECK.
Acetone extract	0.10
Saponifiable acetone extract	0.10
Unsaponifiable resins	0.10
Waxy hydrocarbons	0.10
Free sulfur	0.05
Chloroform extract	0.10
Alcoholic potash extract	0.10
Rubber hydrocarbons	0.20
Total sulfur	0.10

INTERPRETATION.

31. The rubber shall be considered to be the sum of the rubber hydrocarbons, saponifiable acetone extract, unsaponifiable resins and chloroform and alcoholic potash extracts, expressed as percentages. If the chloroform extract is over 3.0 per cent of the rubber so calculated, subtract the excess from the rubber. If the KOH extract is over 1.8 per cent of the rubber as first calculated, subtract this excess also from the rubber. **Interpretation.**

RED LEAD.

32. Dissolve 1 g. of the sample in 75 cc. of xylol at a temperature of about 100° C. When the rubber is dissolved, the absence of any red particles indicates the absence of red lead. If red particles are present, filter the solution into a Gooch crucible and wash thoroughly with benzol, acetone and alcohol successively. Remove the felt and residue to a distilling flask, add HCl, and distill over the chlorine liberated by the lead peroxide, absorbing the gas in a solution of KI and starch. Not more than 0.1 cc. of N/10 thiosulfate shall be required to titrate the iodine liberated. **Red Lead.**

ORGANIC FILLERS.

33. Transfer the first and second decantations of the HCl solutions to a carefully cleaned porcelain dish and add 20 cc. **Organic Filler.**

concentrated H_2SO_4. Place dish on steam bath or hot plate to drive off water and HCl. A pronounced charring of the residue indicates the presence of organic matter soluble in water or hydrolyzed by HCl. Examine filter paper and rubber while decanting acid solution and washing free of chlorides. Some types of organic fillers not removed by water and HCl, would be plainly visible at this point. Place a small portion of residue *C* under a microscope and examine for fibrous and other characteristic organic material. If organic fillers are indicated and not clearly proven by this test, place 1 g. of the original sample in a beaker, add 50 cc. of xylol and heat on hot plate until the rubber is dissolved. Decant xylol solution and wash residue with ether several times by decantation. Dry residue and examine under the microscope.

STATEMENT OF RESULTS.

Statement of Results.

34. The results of the analysis shall be stated in the following form:

	PER CENT.
Acetone extract	....
Saponifiable acetone extract	....
Unsaponifiable resins	....
Waxy hydrocarbons	....
Free sulfur	....
Chloroform extract	....
Alcoholic potash extract	....
Total sulfur	....
Rubber	....
Color of acetone extract (60 cc. vol.)	....
Fluorescence in acetone extract solution (present or absent)	....
Hydrocarbons A (consistency and color)	....
Hydrocarbons B (solid or liquid)	....
Color of chloroform extract (60 cc. vol.)	....
Carbon (present or absent)	....
Red lead (present or absent)	....
Specific gravity	....

AMERICAN SOCIETY FOR TESTING MATERIALS

PHILADELPHIA, PA., U. S. A.

AFFILIATED WITH THE

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS
FOR
RUBBER BELTING FOR POWER TRANSMISSION.[1]

Serial Designation: D 53 – 19 T.

These specifications are issued under the fixed designation D 53; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1918; REVISED, 1919.

Material Covered.

1. These specifications cover two classes of rubber belting for power transmission:

(*a*) *Rubber-Covered.*—Possessing a distinct rubber cover over the outside plies of rubber-frictioned canvas and extending around the edges.

(*b*) *Friction-Covered.*—Possessing no distinct rubber cover other than that imparted to the canvas by the regular rubber frictioning process.

I. MANUFACTURE.

Construction.

2. The belting shall consist of:

(*a*) Cotton reinforcement;
(*b*) Rubber friction compound;
(*c*) An outside rubber cover, when specified.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. E. A. Barrier, Chairman of Committee D-11 on Rubber Products, 31 Milk Street, Boston, Mass.

Reinforcement. 3. The reinforcement shall consist of canvas plies made from cotton duck evenly and firmly woven, as free from such defects as knots, lumps, and irregularities of twist as is consistent with the best manufacturing practice. It shall be well frictioned on both sides with a rubber compound.

Rubber Beading. 4. The seam in the outside ply of frictioned canvas shall be completely filled with a rubber cord, or "beading," well fastened down with a rubber cover-strip.

Rubber Cover. 5. When rubber-covered belting is specified, the rubber cover shall be uniform in thickness, and free from cracks, blisters or other defects which would impair its moisture-resisting qualities.

II. PHYSICAL PROPERTIES AND TESTS.

Standard Methods of Testing. 6. Where applicable, references are made below to the Standard Methods for Testing Cotton Rubber-Lined Hose (Serial Designation: D 15) of the American Society for Testing Materials.[1]

Temperature of Testing Room and Samples. 7. The temperature of the testing room and samples shall be as defined in Section 19 of Standard Methods D 15.

Stretch Test of Belting. 8. From each lot of belting submitted for inspection a section 30 in. in length shall be cut and bench marks placed upon it 18 in. apart; it shall then be tested in a suitable tension testing machine and, under a load of 100 lb. per inch per ply, shall not stretch more than 5 per cent.

Tensile Strength Test of Belting. 9. The stretch test described in Section 8 shall be continued without interruption to the breaking point, which shall occur at not less than 285 lb. per inch per ply. The rate of separation of the jaws shall be approximately $\frac{1}{2}$ in. per minute.

Filler Strength Test of Duck. 10. The filler or weft strength of the cotton duck in the belting shall be determined as follows: A transverse strip $1\frac{1}{2}$ in. wide shall be cut from the belting and opened up into its various plies. Each of these plies shall be ravelled down to a width of 1 in. and tested in a fabric testing machine, the minimum width of jaws of which is $1\frac{1}{2}$ in., the distance between jaws 3 in., and the speed of separation of jaws 20 in. per minute. The tensile strength shall be at least 175 lb.

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[1] 1918 Book of A.S.T.M. Standards.

Strength and Tensile Tests of Belts Wider than 12 in.

11. For belting of greater width than 12 in. the manufacturer shall supply for stretch and tension tests a 30-in. section of belting not more than 12 nor less than 6 in. in width, guaranteed to truly represent the composition of and the treatment given the belting supplied.

Friction Test.

12. (*a*) The friction test or adhesion between the plies shall be conducted in the following manner: Test specimens, each 1 in. in width, two plies in thickness and at least 4 in. in length, shall be prepared in sufficient number to test the adhesion between all plies. These should be taken transversely for belting 4 in. and over in width and longitudinally for lesser widths. The two plies shall be separated for a distance of about $1\frac{1}{2}$ in. and by means of these separated ends, the test specimen shall be mounted freely between the upper fixed pair of jaws and the lower pulling pair of jaws, the latter weighted to 18 lb. The rate of separation under this test shall not be greater than 1 in. per minute.

(*b*) A suitable friction testing machine where available may be used to make the above test, in which case the pull required to cause a stripping of 1 in. per minute shall be not less than 18 lb.

Tests on Cover and Beading.

13. (*a*) With each lot of belting the manufacturer shall be required to furnish for test, sample pieces 8 in. in length, at least 4 in. in width and $\frac{1}{16}$ in. in thickness, one piece consisting of cover compound (when rubber-covered belting has been specified) and the other consisting of beading compound. These sample pieces shall be guaranteed to truly represent, in each case, the composition and degree of vulcanization of the article delivered.

(*b*) The tests shall be conducted in accordance with Sections 18, 20(*a*), 22, 23, 24 and 25 of Standard Methods D 15.

(*c*) When stretched from 2 in. (the original gage length) to 7 in. for the cover, and from 2 in. to 8 in. for the beading, the set or permanent elongation shall not exceed 25 per cent.

(*d*) The tensile strength shall be not less than 800 lb. per sq. in. for the cover and 1100 lb. per sq. in. for the beading.

(*e*) The elongation at the breaking load shall be such that the original 2-in. gage length of the test specimen for the cover shall stretch to not less than 9 in. and for the beading to not less than 10 in.

(*f*) The beading shall also be tested as follows: A 4-in. transverse section of belting shall be taken and beginning on the pulley or seamless side the plies shall be removed until only three remain intact. A line shall be drawn down the middle of the beading and then on each side of this line, and $\frac{5}{8}$ in. distant from it, two parallel lines shall be scribed. The section shall be inserted in a vise so that the jaws grip the sample coincident with the two outer lines. The vise shall be tightened until the inner surfaces of the doubled sample just touch at the top of the vise, and the sample shall be so held for 10 minutes. Under this test the beading shall not crack or loosen in the seam.

III. PERMISSIBLE VARIATIONS IN SIZES.

Width of Belting

14. The width of the belting shall be not less than that specified by the purchaser, and shall not exceed that specified by more than the following limits:

WIDTH.	PERMISSIBLE PLUS VARIATIONS, IN.
Up to 12 in., incl.	$\frac{1}{8}$
Over 12 to 24 in., incl.	$\frac{3}{16}$
Over 24 in., incl	$\frac{1}{4}$

Thickness of Belting.

15. The thickness of the belting in inches shall be not less than 0.050 multiplied by the number of plies, plus the thickness of the rubber covers, if any.

Thickness of Cover.

16. The cover shall be not less than $\frac{3}{128}$ (=0.023) in. in thickness. This shall also apply to the edges.

IV. MARKING.

Marking.

17. Each roll of belting shall have the name of the manufacturer, the month and year of manufacture, the trade name of the belt, and the legend "Power A.S.T.M. Specifications" impressed in the strip side at points not more than 15 ft. apart.

Precaution.

18. Each roll of belting shall have the following words stencilled on the strip side, on the outside ply of the roll: "Run other side to pulley."

Endless Belts.

19. Endless belts shall have additional marks showing in which direction the belt shall be run with regard to the splices.

V. INSPECTION AND REJECTION.

Inspection.

20. (*a*) The manufacturer shall notify the purchaser sufficiently in advance of the completion of the belting to permit of arrangement for inspection.

(*b*) The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the belting is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*c*) The purchaser may make the tests to govern the acceptance or rejection of the belting in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

Rehearing.

21. Samples of rejected belting shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

AMERICAN SOCIETY FOR TESTING MATERIALS

PHILADELPHIA, PA., U. S. A.

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INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS
FOR
STEAM HOSE.[1]

Serial Designation: D 54 – 18 T.

These specifications are issued under the fixed designation D 54; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1918.

Material Covered. 1. These specifications cover wrapped steam hose, suitable for steam heat connections when the steam pressure does not exceed 125 lb. per sq. in.

I. MANUFACTURE.

Construction. 2. The hose shall consist of:

(*a*) An inner rubber tube;
(*b*) Cotton reinforcement;
(*c*) An outer rubber cover.

Rubber Tube. 3. The rubber tube shall be smooth, uniform in quality and thickness, and free from injurious defects.

Cotton Reinforcement. 4. The reinforcement shall consist of long fiber cotton having 5 threads per strand, and not less than 16 nor more than 22 strands per inch of width, for both warp and filler.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. E. A. Barrier, Chairman of Committee D-11 on Rubber Products, 31 Milk Street, Boston, Mass.

The duck shall be cut and applied on a bias, of from 42 to 46 deg., with edges lapped at least 0.5 in. and with both sides well frictioned.

Rubber Cover. 5. The rubber cover shall be uniform in quality and thickness, and free from injurious defects.

II. PHYSICAL PROPERTIES AND TESTS.

Standard Methods of Testing. 6. Where applicable, references are made below to the Standard Methods for Testing of Cotton Rubber-Lined Hose (Serial Designation: D 15) of the American Society for Testing Materials.[1]

Temperature of Testing Room and Samples. 7. The temperature of the testing room and samples shall be as defined in Section 19 of Standard Methods D 15.

Samples for Tests. 8. A portion 18 in. long shall be cut from each length of hose, except in the case of 22, 24 or 30-in. lengths, when one length from each 200 ft. or less shall be taken for test. A portion $2\frac{1}{2}$ in. long shall be cut from the test specimen and subjected to the tests specified in Section 9. The remaining portion of the test specimen shall then have the exposed ends coated with a covering of rubber cement and be subjected to the digester test as specified in Section 12, after which another $2\frac{1}{2}$-in. portion shall be cut from the test specimen and subjected to the tests specified in Section 10.

Friction Test before Steaming. 9. The quality of the rubber friction binding the plies together shall be determined by suspending a 20-lb. weight from the separated end of the duck of a 1-in. test ring cut from the $2\frac{1}{2}$-in. sample described in Section 8, the force being applied radially. The rate of separation of the plies shall not be greater than 1 in. per minute. The test shall extend for 10 minutes when the size of hose permits.

Friction Test after Steaming. 10. The quality of the rubber friction after steaming shall be determined, as described in Section 9, on a 1-in. test ring cut from the sample after it has been subjected to the digester test, except that a 15-lb. weight shall be used in place of the 20-lb. weight described in Section 9.

Tests of Tube and Cover. 11. (*a*) The tests of tube and cover shall be conducted in accordance with Sections 18, 20 (*a*), (*b*), and (*c*), 21, 22, 23, 24, and 25 of Standard Methods D 15.

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[1] 1918 Book of A.S.T.M. Standards.

(*b*) The friction between the inner tube and cotton duck shall be the same as that between the plies.

(*c*) The tensile strength before steaming shall be not less than 600 lb. per sq. in.

(*d*) The tensile strength after steaming shall be not less than 450 lb. per sq. in.

(*e*) For both the tube and cover, the elongation at the breaking load shall be such that the original 2-in. gage length shall stretch to not less than 6 nor more than 10 in. before steaming, and to not less than 4 nor more than 8 in. after steaming.

Digester Test.

12. The digester shall consist of a closed cylinder containing dry saturated steam at a pressure of 45 lb. per sq. in. The test specimen specified in Section 8 shall be placed in the digester and shall remain there for 48 hours continuously. An examination of the section after being subjected to the heat of the steam should be made immediately after removal from the digester, and should disclose no blistering of the inner tube or loosening of the tube from the fabric. Tests after steaming prescribed in the specifications shall be made as soon as possible after the specimen has cooled for 24 hours.

III. SIZES AND DIMENSIONS.

Sizes and Dimensions.

13. (*a*) Steam hose shall be in accordance with the sizes and dimensions specified by the purchaser.

(*b*) The thickness of cover shall be not less than $\frac{1}{16}$ in. The thickness of tube shall be not less than $\frac{1}{8}$ in.

IV. WORKMANSHIP.

Workmanship.

14. The hose shall conform to the dimensions specified and shall be finished in a workmanlike manner. The tube and cover shall be free from injurious defects.

V. MARKING.

Marking.

15. (*a*) Each 50-ft. length of hose shall have inlaid in rubber in three places, namely, midway between the ends and within

10 ft. of each end, a brand showing the name of the manufacturer, the month and year of manufacture, the trade name of the hose, and the legend "A.S.T.M. Specifications." Shorter lengths than 50 ft. shall have one brand similar to the above inlaid in rubber.

(*b*) Serial numbers of rejected hose shall not be applied to any other hose during the same calendar year.

VI. INSPECTION AND REJECTION.

Inspection.

16. (*a*) The manufacturer shall notify the purchaser sufficiently in advance of the completion of the hose to permit of arrangement for inspection.

(*b*) The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the hose is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*c*) The purchaser may make the tests to govern the acceptance or rejection of the hose in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

Rejection.

17. Samples of rejected hose shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

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TENTATIVE SPECIFICATIONS
FOR
LEADER HOSE FOR USE WITH PNEUMATIC TOOLS.[1]

Serial Designation: D 60 – 19 T.

These specifications are issued under the fixed designation D 60; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

Material Covered. 1. (*a*) These specifications cover leader hose for air tools working at not more than 125 lb. pressure.

(*b*) The hose is of two classes:

(*A*) *Braided Leader Hose* has a reinforcement of three plies of braided cotton yarn between the inner tube and the outer rubber cover;

(*B*) *Wrapped Leader Hose* has a reinforcement of plies of cotton canvas between the inner rubber tube and the outer rubber cover.

I. MANUFACTURE.

Construction. 2. The hose shall consist of:

(*a*) An inner rubber tube;
(*b*) Cloth braided layers or canvas plies;
(*c*) An outer rubber cover;
(*d*) A wire armor when specified.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1920, to Mr. E. A. Barrier, Chairman of Committee D-11 on Rubber Products, 31 Milk Street, Boston, Mass.

Inner Tube. 3. The inner rubber tube shall be smooth, uniform in quality, and thickness and free from injurious defects.

Cotton Reinforcement. 4. (*a*) The reinforcement of braided leader hose shall consist of three plies of cotton braided layers evenly and firmly woven over the inner tube. Each layer shall be well impregnated with a rubber compound suitable for the required service.

(*b*) The reinforcement of wrapped leader hose shall consist of cotton canvas cut on a 45-deg. bias and applied evenly and firmly over the inner tube. Each ply shall be well frictioned on both sides with rubber compound.

(*c*) The cotton shall be as free from unsightly defects, dirt, knots, lumps and irregularities of twist as is consistent with the best manufacturing practice.

(*b*) The reinforcement shall be sufficiently strong to enable the hose to successfully withstand the hydrostatic pressure test, yet at the same time be soft and pliable.

Outer Rubber Cover. 5. The rubber cover shall be uniform in quality and thickness, and free from injurious defects.

Wire Armor. 6. When specified, the hose shall be given an extra covering of armor of half-round galvanized steel wire $\frac{7}{32}$ by $\frac{3}{64}$ in. ,wrapped with $\frac{1}{4}$ in. space between adjacent wires.

II. PHYSICAL PROPERTIES AND TESTS.

Standard Methods. 7. Where applicable, references are made below to the Standard Methods for Testing of Cotton Rubber-Lined Hose (Serial Designation: D 15) of the American Society for Testing Materials.[1]

Temperature of Testing Room and Samples. 8. The temperature of testing room and samples shall be as defined in Section 19 of Standard Methods D 15.

Samples for Testing Rubber Parts. 9. Prior to the hydrostatic test specified in Section 12 (*b*), a section of hose 16 in. long shall be cut at any place from each test length and subjected to the following tests:

Friction Test. 10. The adhesive quality of the rubber impregnation binding the plies together shall be determined in the case of braided leader hose by suspending a 20-lb. weight from the separated end of a ply having a 1-in. section, cut longitudinally from the 16-in. sample described in Section 9.

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[1] 1918 Book of A.S.T.M. Standards.

In the case of wrapped leader hose it shall be determined by suspending a 20-lb. weight from the separated end of the duck of a 1-in. test ring cut from the 16-in. sample described in Section 9, the force being applied radially.

In both cases the rate of separation of the plies shall not be greater than 1 in. per minute.

Test of Rubber Tube and Cover.

11. (*a*) The tests of tube and cover shall be conducted in accordance with Sections 18, 19, 20, 22, 23, 24 and 25 of the Standard Methods D 15.

(*b*) Test specimen shall be cut longitudinally of the hose.

(*c*) When stretched from 2 in. (the original gage length) to 9 in., the stress in the specimen from the tube shall be at least 1000 lb. per sq. in. and in that from the cover at least 800 lb. per sq. in.

(*d*) The set, or permanent elongation following a stretch from 2 in. to 9 in., shall not exceed 25 per cent.

(*e*) The tensile strength shall be not less than 1500 lb. per sq. in. for the tube and 1300 lb. per sq. in. for the cover.

(*f*) The elongation at the breaking load shall be such that the original 2-in. gage length of the test specimens for both the tube and cover shall stretch to not less than 11 in.

Hydrostatic Pressure.

12. (*a*) The method of conducting the hydrostatic pressure tests shall be in accordance with Section 26 of Standard Methods D 15.

(*b*) Each length of hose shall be subjected to a proof pressure test of 250 lb. per sq. in. for five minutes to expose imperfections. On armored hose this test shall be made after the removal of the armoring.

(*c*) From each lot of ten lengths or less of hose inspected, one length shall be further subjected to a pressure test of 800 lb. per sq. in. for 10 minutes, which it shall withstand without bursting. On large orders the number of tests may be reduced to not less than three at the option of the inspector representing the purchaser.

III. STANDARD DIMENSIONS AND WEIGHTS.

Length and Weight.

13. Unless otherwise specified, the hose shall be furnished in 10-ft. lengths, which shall weigh not more than 4 lb. The ends of each length shall be uncapped and without fittings.

Thickness.

14. (*a*) The minimum tube and cover thickness shall be as follows:

INTERNAL DIAMETER OF HOSE, IN.	MINIMUM TUBE THICKNESS, IN.	MINIMUM COVER THICKNESS, IN.
$\frac{7}{16}$	$\frac{3}{32}$	$\frac{1}{16}$

(*b*) The gage of tube and cover shall be measured with the braid embedded in the rubber.

IV. MARKING.

Marking.

15. Each length of hose shall have inlaid in rubber, midway between the ends, a brand showing the name of the manufacturer, the month and year of manufacture, the trade name of the hose and the legend "Leader 125 lb. A.S.T.M. Specifications."

V. INSPECTION AND REJECTION.

Inspection.

16. (*a*) The manufacturer shall notify the purchaser sufficiently in advance of the completion of the hose to permit of arrangements for inspection.

(*b*) The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the hose is being furnished in accordance with these specifications. The tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*c*) The purchaser may make the tests to govern the acceptance or rejection of the hose in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

Rehearing.

17. Samples of rejected hose shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

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TENTATIVE TEST
FOR
VISCOSITY OF LUBRICANTS.[1]

Serial Designation: D 47 - 19 T.

This test is issued under the fixed designation D 47; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

Viscosity. 1. Viscosity shall be determined by means of the Saybolt Standard Universal Viscosimeter.

Apparatus. 2. (*a*) The Saybolt Standard Universal Viscosimeter (see Fig. 1) is made entirely of metal. The standard oil tube *J* is fitted at the top with an overflow cup *E*, and the tube is surrounded by a bath *L*. At the bottom of the standard oil tube is a small outlet tube through which the oil to be tested flows into a receiving flask *R*, whose capacity to a mark on its neck is 60 (±0.15) cc. The lower end of the outlet tube is enclosed by a larger tube, which when stoppered by a cork, *N*, acts as a closed air chamber and prevents the flow of oil through the outlet tube until the cork is removed and the test started. A looped string is attached to the lower end of the cork as an aid to its rapid removal. The bath is provided with two stirring paddles

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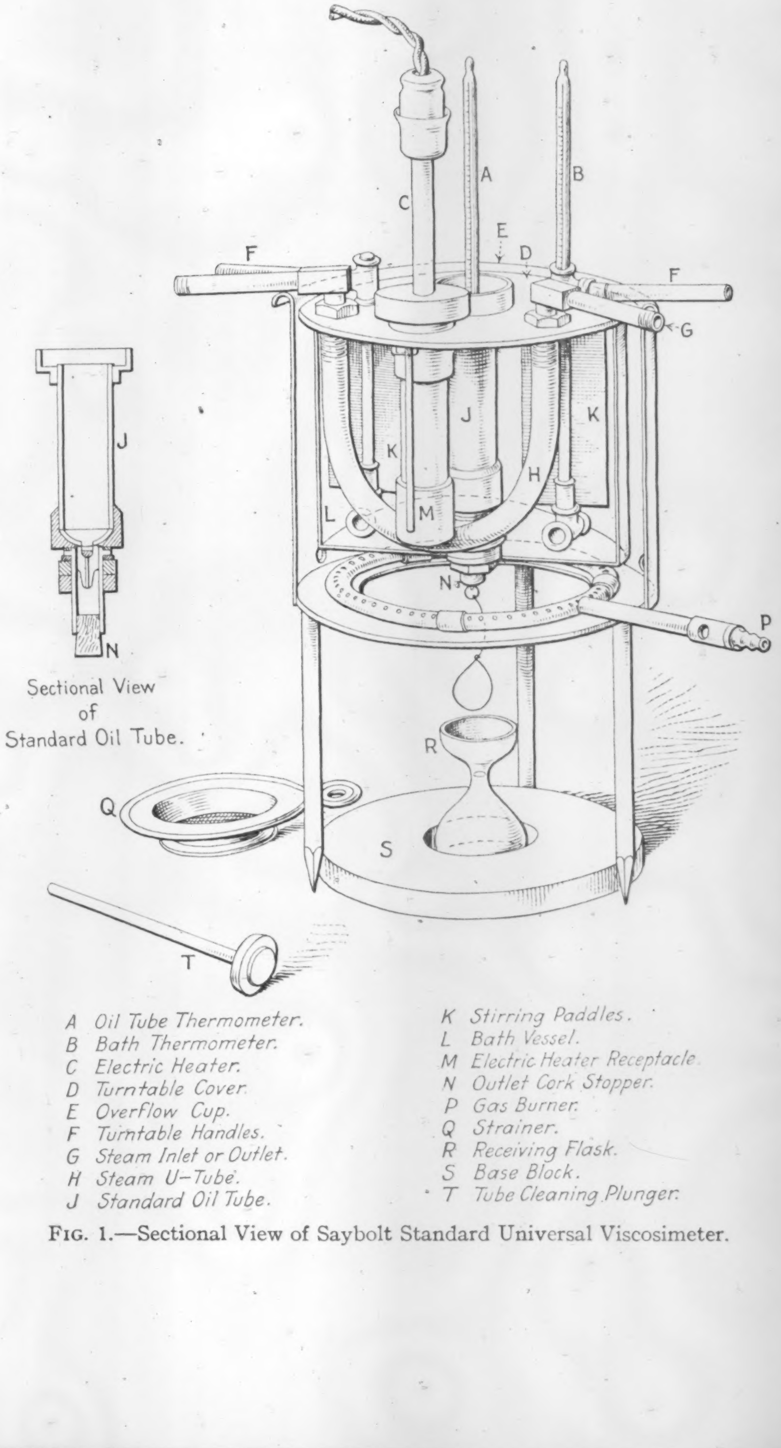
[1] Criticisms of this Tentative Test are solicited and should be directed, preferably before January 1, 1920, to Mr. C. P. Van Gundy, Chairman of Committee D-2 on Lubricants, Baltimore & Ohio Railroad, Mont Clare, Baltimore, Md.

This test, when adopted as standard, will be added to the present Standard Tests for Lubricants (Serial Designation: D 47 - 18), 1918 Book of A.S.T.M. Standards.


A
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Sectional View
of
Standard Oil Tube.
A Oil Tube Thermometer.
B Bath Thermometer.
C Electric Heater.
D Turntable Cover.
E Overflow Cup.
F Turntable Handles.
G Steam Inlet or Outlet.
H Steam U-Tube.
J Standard Oil Tube.
K Stirring Paddles.
L Bath Vessel.
M Electric Heater Receptacle.
N Outlet Cork Stopper.
P Gas Burner.
Q Strainer.
R Receiving Flask.
S Base Block.
T Tube Cleaning Plunger.

FIG. 1.—Sectional View of Saybolt Standard Universal Viscosimeter.

K and operated by two turn-table handles *F*. The temperatures in the standard oil tube and in the bath are shown by thermometers, *A* and *B*. The bath may be heated by a gas ring burner *P*, steam U-tube *H*, or electric heater *C*. The standard oil tube is cleaned by means of a tube cleaning plunger *T*, and all oil entering the standard oil tube shall be strained through a 30-mesh brass wire strainer *Q*. A stop watch is used for taking the time of flow of the oil and a pipette, fitted with a rubber suction bulb, is used for draining the overflow cup of the standard oil tube.

(*b*) The standard oil tube, *J*, should be standardized by the U. S. Bureau of Standards, Washington, D. C., and shall conform to the following dimensions:

DIMENSIONS.	MINIMUM, CM.	NORMAL, CM.	MAXIMUM, CM.
Inside diameter of outlet tube	0.1750	0.1765	0.1780
Length of outlet tube	1.215	1.225	1.235
Height of overflow rim above bottom of outlet tube	12.40	12.50	12.60
Diameter of container of standard oil tube	2.955	2.975	2.995
Outer diameter of outlet tube at lower end	0.28	0.30	0.32

Method. 3. Viscosity shall be determined at 100° F. (37°.8 C.), 130° F. (54°.4 C.), or 210° F. (98°.9 C.). The bath shall be held constant within 0°.25 F. (0.14° C.) at such a temperature as will maintain the desired temperature in the standard oil tube. For viscosity determinations at 100 and 130° F., oil or water may be used as the bath liquid. For viscosity determinations at 210° F., oil shall be used as the bath liquid. The oil for the bath liquid should be a pale engine oil of at least 350° F. flash point (open cup). Viscosity determinations shall be made in a room free from draughts, and from rapid changes in temperature. All oil introduced into the standard oil tube, either for cleaning or for test, shall first be passed through the strainer.

To make the test, heat the oil to the necessary temperature and clean out the standard oil tube with the plunger, using some of the oil to be tested. Place the cork stopper into the lower end of the air chamber at the bottom of the standard oil tube. The stopper should be sufficiently inserted to prevent the escape of air, but should not touch the small outlet tube of the standard oil tube. Heat the oil to be tested, outside the viscosimeter, to slightly below the temperature at which the viscosity is to be determined and pour it into the standard oil tube until it ceases to overflow into the overflow cup. By means of the oil tube thermometer keep the oil in the standard oil tube well stirred and also stir well the oil in the bath. It is extremely important that the temperature of the oil in the oil bath be maintained constant during the entire time consumed in making the test. When the temperature of the oil in the bath and in the standard oil tube are constant and the oil in the standard oil tube is at the desired temperature, withdraw the oil tube thermometer; quickly remove the surplus oil from the overflow cup by means of a pipette so that the level of the oil in the overflow cup is below the level of the oil in the tube proper; place the 60-cc. flask in position so that the oil from the outlet tube will flow into the flask without making bubbles; snap the cork from its position, and at the same instant start the stop watch. Stir the liquid in the bath during the run and carefully maintain it at the previously determined proper temperature. Stop the watch when the bottom of the meniscus of the oil reaches the mark on the neck of the receiving flask.

The time in seconds for the delivery of 60 cc. of oil is the Saybolt viscosity of the oil at the temperature at which the test was made.

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TENTATIVE TEST
FOR
LOSS ON HEATING OF OIL AND ASPHALTIC COMPOUNDS.[1]

Serial Designation: D 6 – 19 T.

This test is issued under the fixed designation D 6; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

1. This test is used to determine the loss in weight (exclusive of water) of oil and asphaltic compounds when heated as hereinafter prescribed. The material under examination must therefore first be tested for water and if water is found to be present, it must be removed by suitable methods of dehydration before the material is subjected to the loss on heating test; or another sample obtained which is free from water.

I. APPARATUS.

Oven. 2. The oven may be either circular or rectangular in form and may be heated by either gas or electricity. Its interior dimensions shall be as follows: height, not less than 40.64 cm.

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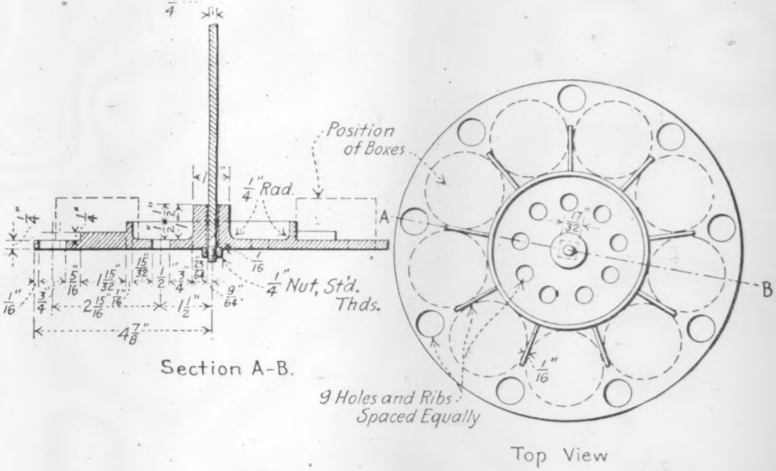
[1] Criticisms of this Tentative Test are solicited and should be directed, preferably before January 1, 1920, to Mr. Prévost Hubbard, Secretary of Committee D 4 on Road Materials, 15 Maiden Lane, New York City.

This test, when adopted as standard, will supersede the present Standard Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6-16), 1918 Book of A.S.T.M. Standards.

(16 in.); width and depth or diameter, at least 4.08 cm. (2 in.) greater than the diameter of the revolving shelf.

It shall be well ventilated and shall be fitted with a window in the upper half of the door, so placed and of sufficient size to permit the accurate reading of the thermometer without opening the door. It shall also be provided with a perforated circular shelf preferably of approximately 24.8 cm. (9.75 in.) in diameter. This shelf shall be placed in the center of the oven and shall be suspended by a vertical shaft and provided with mechanical means for rotating it at the rate of 5 to 6 revolutions per minute.



1/4
1/4"
1/4"
1/2"
1/2"
1"
1/4" Rad.
Position of Boxes
A
B
1/16"
3/4"
5/16"
1 15/32"
1/16"
15/32"
1/2
3/4
23/64"
9/64"
1/16
1/4" Nut, Std. Thds.
2 15/16"
1 1/2"
4 7/8"
17/32"
1/16"
9 Holes and Ribs Spaced Equally

Section A-B.

Top View

FIG. 1.—Aluminum Shelf.

It shall be provided with recesses equidistant from the central shaft in which the tins containing the samples are to be placed. (A recommended form of aluminum shelf is shown in Fig. 1).

Thermometer. 3. The thermometer shall be between 12.7 cm. (5 in.) and 15.24 cm. (6 in.) in length and the mercury bulb shall be from 10 to 15 mm. (0.39 to 0.59 in.) in length. The scale shall be engraved on the stem, shall be clear cut and distinct, and shall run from 150 to 175° C. (302 to 347° F.) in 1° C. divisions and shall commence substantially 3.81 cm. ($1\frac{1}{2}$ in.) above the top of the bulb. Every fifth graduation shall be larger than the intermediate ones and shall be numbered. The degrees shall be substantially 3.17 mm. ($\frac{1}{8}$ in.) apart. The thermometer shall be furnished with an expansion chamber at the top and have a ring for attaching tags. It shall be made of a suitable quality of glass and be so annealed as to not change its readings under conditions of use. It shall be correct to 0°.25 C. (0°.45 F.) as determined by comparison at full immersion with a similar thermometer calibrated at full immersion by the United States Bureau of Standards.

Container.

4. The container in which the sample is to be tested shall be of tin, cylindrical in shape, and shall have a flat bottom. Its inside dimensions shall be substantially as follows: diameter, 55 mm. (2.17 in.); depth, 35 mm. (1.38 in.). (A 3-oz. Gill style ointment box, deep pattern, fulfills these requirements.)

II. PREPARATION OF SAMPLE.

Preparation of Sample.

5. The sample as received shall be thoroughly stirred and agitated, warming, if necessary, to insure a complete mixture before the portion for analysis is removed.

III. TESTING.

Testing.

6. Weigh 50 g. of the water-free material to be tested into a tared container conforming to the requirements of Section 4. Bring the oven to a temperature of 163° C. (325° F.), and place the tin box containing the sample in one of the recesses of the revolving shelf. The thermometer shall be immersed for the depth of its bulb in a separate 50-g. sample of the material under test, placed in a similar container, and shall be conveniently suspended from the vertical shaft. This sample shall rest in one of the recesses upon the same shelf and revolve with the sample or samples under test. Then close the oven and rotate the shelf 5 to 6 revolutions per minute during the entire test. Maintain the temperature at 163° C. (325° F.) for 5 hours, then remove the sample from the oven, cool and weigh, and calculate the loss due to volatilization.

Permissible Variation in Temperature.

7. During the 5-hour period the temperature shall not vary more than 1° C. All tests showing a greater variation in temperature shall be rejected.

IV. ACCURACY.

Accuracy. 8. Up to 5 per cent loss in weight the results obtained may be considered as correct within 0.5. Above 5 per cent. loss in weight the numerical limit of error increases 0.01 for every 0.5 per cent increase in loss by volatilization as follows:

VOLATILIZATION LOSS, PER CENT.	NUMERICAL CORRECTION.	TRUE VOLATILIZATION LOSS, PER CENT.
5.0	±0.50	4.50 to 5.50
5.5	±0.51	4.91 " 6.01
6.0	±0.52	5.48 " 6.52
10.0	±0.60	9.40 " 10.60
15.0	±0.70	14.30 " 15.70
25.0	±0.90	24.10 " 25.90
40.0	±1.20	38.80 " 41.20

V. PRECAUTIONS.

Precautions. 9. Under ordinary circumstances a number of samples having about the same degree of volatility may be tested at the same time. Samples varying greatly in volatility should be tested separately. Where extreme accuracy is required not more than one material should be tested at one time and duplicate samples of it should be placed simultaneously in the oven. Such duplicates shall check within the limits of accuracy given above. Results obtained on samples showing evidences of foaming during the test shall be rejected.

NOTE.

If additional periods of heating are desired, it is recommended that they be made in successive increments of 5 hours each.

When the penetration of the sample after heating is required, melt the residue in the container at the lowest possible temperature and thoroughly mix by stirring, taking care to avoid incorporating air bubbles in the mass. Then bring it to the standard temperature and test as prescribed under the directions for the Standard Test for Penetration of Bituminous Materials (Serial Designation: D 5) of the American Society for Testing Materials.[1]

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[1] 1918 Book of A.S.T.M. Standards.

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TENTATIVE TESTS
FOR
MOLDED INSULATING MATERIALS.[1]

Serial Designation: D 48 – 17 T.

These tests are issued under the fixed designation D 48; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

Material Covered. 1. These tests are intended to apply to all solid insulating materials that are formed in molds or between platens by the application of pressure, either with or without heat.

I. PHYSICAL PROPERTIES AND TESTS.

(*A*) *Mechanical.*

TENSILE STRENGTH.

Specimen. 2. The standard test specimen shown in Fig. 1 shall be used for the tension test. It shall be molded in a hardened and ground steel mold to the dimensions given in Fig. 1.

Apparatus. 3. Any standard testing machine may be used. Special clips (see Fig. 1) of hardened steel shall be used, hung from links held in the jaws of the machine, so that the pull is central at all times, to avoid any transverse strain.

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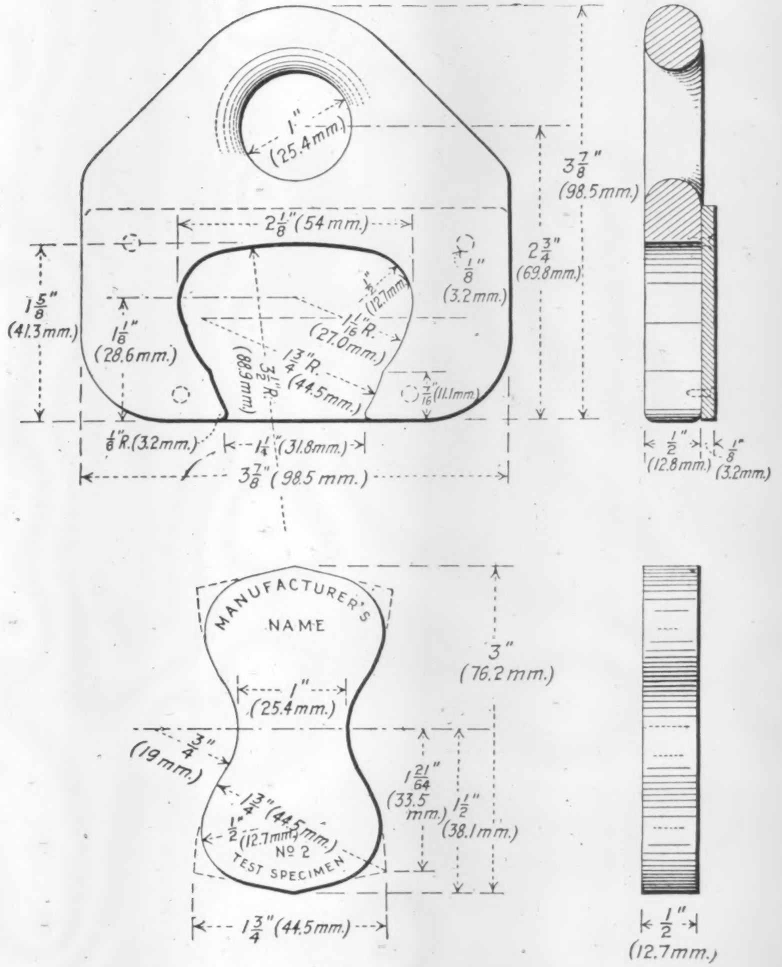
[1] Criticisms of these Tentative Tests are solicited and should be directed, preferably before January 1, 1920, to Mr. C. E. Skinner, Chairman of Committee D-9 on Electrical Insulating Materials, W. E. & M. Co., East Pittsburgh, Pa.


1" (25.4mm.)
3 7/8" (98.5mm.)
2 1/8" (54 mm.)
2 3/4" (69.8mm.)
1/8" (3.2mm.)
1 5/8" (41.3mm.)
1 1/8" (28.6mm.)
1/2" (12.7mm.)
1 1/16" R. (27.0mm.)
1 3/4" R. (44.5mm.)
3 1/2" R. (88.9mm.)
7/16" (11.1mm.)
1/8" R. (3.2mm.)
1 1/4" (31.8mm.)
3 7/8" (98.5 mm.)
1/2" (12.8mm.)
1/8" (3.2mm.)
MANUFACTURER'S NAME
3" (76.2mm.)
1" (25.4mm.)
3/4" (19mm.)
1 21/64" (33.5 mm.)
1 1/2" (38.1mm.)
1 3/4" (44.5mm.)
1/2" (12.7mm.)
No 2 TEST SPECIMEN
1 3/4" (44.5mm.)
1/2" (12.7mm.)

Make Steel Mold to these Dimensions. Limits ± 0."002 (0.05mm.)

FIG. 1.—Tension Test Specimen (Specimen No. 2.)

Method. 4. (*a*) Six specimens shall be tested in the condition in which they are received.

Three specimens shall be tested after heating in an oven for one hour at a temperature which is 10° C. (18° F.) below the distortion point of the material, as determined under Part (*C*), Sections 18 to 21. The test shall be made while the specimens are hot, with a permissible variation of ±5 per cent from the temperature taken.

Three specimens shall be tested after they have been entirely immersed in distilled water for 48 hours at normal room temperature. The specimens shall be pulled apart at normal room temperature of about 21° C. (70° F.) after the surface water has been removed by wiping with a dry cloth.

(*b*) The test specimen shall be pulled apart at such a speed that the beam can be kept well balanced. Make all tests at normal room temperature of about 21° C. (70° F.). Measurements may be taken at intervals during the test to show the elongation of the specimen when required for elastic materials.

Report. 5. The results of the test shall be reported in the following order:

(*a*) The breaking load of each specimen in kilograms or pounds;

(*b*) The thickness in centimeters or inches as measured by micrometer at the point of fracture;

(*c*) The average ultimate tensile strength in kilograms per square centimeter or in pounds per square inch, as calculated from the actual area of the specimen measured at the point of fracture;

(*d*) State the character of the material tested and describe how it acts under strain;

(*e*) The speed in centimeters or inches per minute at which the jaws traveled during the test.

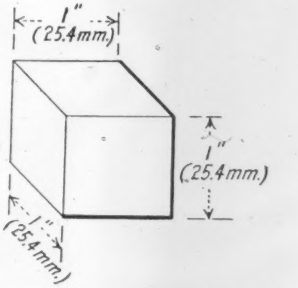
COMPRESSIVE STRENGTH.

Specimen. 6. The test specimen shall be molded in the form of a cube from a hardened steel mold, ground to the dimensions shown in Fig. 2.

Apparatus. 7. Any standard testing machine may be used. The pressure head used for standard compressive strength test on cement blocks is satisfactory for this purpose. Place a sheet of lead $\frac{1}{16}$ in. thick both above and below the specimen to adjust irregularities.

Method. 8. (*a*) Six specimens shall be crushed in the condition in which they are received.

Three specimens shall be crushed after heating for one hour at a temperature which is 10° C. below the distortion point of the material, as determined under Part (*C*), Sections 18 to 21. The test shall be made while the specimens are hot, with a permissible variation of ±5 per cent from the temperature taken.



Manufacturer's Name and "Test Specimen No. 3" Molded on Top in Small Round Body Raised Letters.
Make Steel Mold to these Dimensions.
Limits ± 0."002 (0.05mm.)

FIG. 2.—Compression Test Specimen (Specimen No. 3).

Three specimens shall be crushed after immersion in distilled water at normal room temperature for 48 hours, with all surface water wiped off with a dry cloth.

(*b*) The load shall be applied at such a rate of speed that will permit the beam to be kept well balanced, from zero load until the specimen is crushed. For best results use the slowest possible speed.

Report. 9. The results of the test shall be reported in the following order:

(*a*) The dimensions of each specimen in millimeters or in inches;

(*b*) The breaking load in kilograms or in pounds, on each specimen at the first sign of failure.

(*c*) The average ultimate compressive strength in kilograms per square centimeter or in pounds per square inch, of each set of specimens, calculated from the measured area of each specimen before the load is applied.

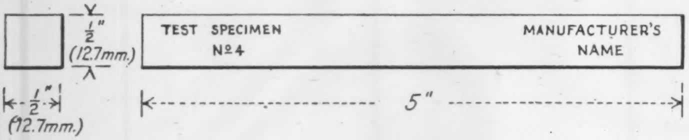
(*d*) State the general character of the material tested and describe how it acts under the applied load;

(*e*) The speed in centimeters or inches per minute at which the jaws traveled during the test.

TRANSVERSE STRENGTH.

Specimen. 10. The test specimen shall be molded from a hardened steel mold, ground to the dimensions shown in Fig. 3.

Apparatus. 11. Any standard testing machine may be used. The specimen shall be supported on two steel blocks, with corners rounded to $1\frac{1}{2}$-mm. ($\frac{1}{16}$-in.) radius. These supports shall be 100 mm. (3.94 in.) apart. The load shall be applied on top of this specimen by means of a wedge-shaped pressure piece, the edge of which is rounded to a 3-mm. ($\frac{1}{8}$-in.) radius, extending across the specimen with the edge parallel to the edges of the two supports. The angle of the wedge shall be approximately 45 deg., and the load shall be applied at right angles to the specimen midway between the supports. The specimen shall be laid flat upon the supports at equal distances from the edges at each end.



Make Steel Mold to these Dimensions. Limits ± 0."002 (0.05 mm.)

FIG. 3.—Transverse Test Specimen (Specimen No. 4).

Method. 12. (*a*) Six specimens shall be tested in the condition in which they are received.

Three specimens shall be tested after immersion in distilled water at normal room temperature for 48 hours, with all surface water wiped off with a dry cloth.

(*b*) The load shall be applied at as slow a speed as possible, so that the beam may be kept well balanced from zero load until the first sign of failure. All tests shall be made at room temperature of about 21° C. (70° F.). Measurements of the deflection may be taken for very elastic materials.

Report. 13. The results of the test shall be reported in the following order:

(*a*) The thickness of each specimen as measured by micrometer in millimeters or in inches;

(*b*) The actual breaking load of each specimen in kilograms or in pounds at the first sign of failure.

(*c*) The maximum fiber stress in kilograms per square centimeter or in pounds per square inch calculated by the formula,

$$S=\frac{3\,PL}{2\,BD^2},$$

in which S = maximum fiber stress, P = load applied, L = distance between the supports, B = width of specimen, and D = depth of specimen;

(*d*) The rate at which the load was applied;

(*e*) The amount of deflection in millimeters or inches.

(*B*) *Electrical.*

DIELECTRIC STRENGTH.

Specimen. 14. The test specimen shall be molded to the dimensions shown in Fig. 4. The mold shall be hardened and ground to these dimensions. If the material cannot be molded to the full height shown, the height can be reduced to $1\frac{1}{4}$ in., other dimensions remaining the same.

Apparatus. 15. (*a*) Any well-designed high tension testing transformer, connected to an alternating current supply having as nearly a true sine wave as possible, may be used. The transformer and the source of supply of energy shall not be less than 5 KVA. The frequency shall not exceed 100 cycles per second.

(*b*) Regulation shall be so controlled that the high tension testing voltage taken from the secondary of the testing transformer can be raised gradually from any point. The control may be made by generator field regulation, by the potentiometer method, with an induction regulator, or with a variable ratio auto transformer. Any method of regulating the voltage is satisfactory which does not distort the wave more than ten per cent from a sinusoidal shape.

(*c*) The voltage may be measured by any approved method, preferably by connecting a voltmeter to an auxiliary ratio transformer coil, reading square root of mean square volts in the primary of the testing transformer. A voltmeter on the low tension side of the transformer is satisfactory, if the ratio of transformation does not change under any test condition. An electrostatic voltmeter properly calibrated in the high tension circuit is also satisfactory. A spark gap may be used to check the readings at very high potentials.

Some protection is desirable in the high tension circuit of testing transformers where the voltage is from 25,000 to 100,000 volts, to prevent dangerous surges and limit the current when the test specimen is punctured. It is, however, desirable to have as much energy available as possible when puncture occurs. If impedance in the form of choke coils be used in series with the high tension terminals, it should not be greater than that which will limit the high tension current to double the normal rated current of the testing transformer.

When a spark gap is used a non-inductive resistance of about 1 ohm per volt may be inserted in series with one terminal of the spark gap, to damp high frequency oscillations at the time of breakdown and limit the current flow. This resistance shall be as near the gap as possible and in series with the test specimen. If the test is made with one side grounded this resistance shall be on the ungrounded side of the circuit, and if neither side is grounded the resistance shall be inserted one-half on each side of the spark gap. Water tube resisters are preferable to carbon for this purpose, as carbon resistance may become very low at high voltage.

(*d*) The apparatus used shall meet the requirements of the Standardization Rules of the American Institute of Electrical Engineers.

Method. 16. (*a*) Voltage shall be applied to the test specimen by placing a wet clay pat about $\frac{1}{4}$ in. thick inside the specimen and extending all around to the wall and another wet clay pat

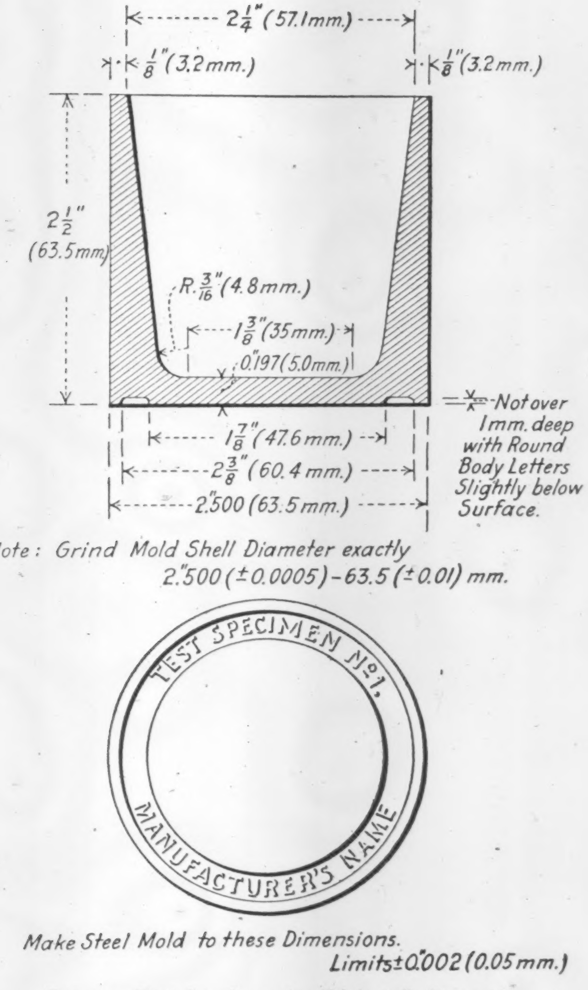

2¼" (57.1 mm.)
⅛" (3.2 mm.)
⅛" (3.2 mm.)
2½" (63.5 mm.)
R. 3/16" (4.8 mm.)
1⅜" (35 mm.)
0."197 (5.0 mm.)
1⅞" (47.6 mm.)
2⅜" (60.4 mm.)
2."500 (63.5 mm.)
Not over 1 mm. deep with Round Body Letters Slightly below Surface.
Note: Grind Mold Shell Diameter exactly 2."500 (±0.0005) - 63.5 (±0.01) mm.
TEST SPECIMEN No. 1.
MANUFACTURER'S NAME
Make Steel Mold to these Dimensions.
Limits ±0."002 (0.05 mm.)

FIG. 4.—Test Specimen for Dielectric Strength (Specimen No. 1).

on the bottom extending to within about ⅛ in. of the edge. Whenever it is impossible to puncture the specimen in air without arcing over the edge, it shall be deeply immersed in high grade transformer oil. On specimens which require a very high voltage to puncture it may be necessary to put a glass tube or shield over the wire leading to the inside in order to prevent breakdown over the surface of the oil between terminals. The testing voltage shall be raised from zero at a constant rate of approximately 1000 volts per second until puncture occurs.

(*b*) Ten specimens shall be punctured in the condition received at normal room temperature of about 21° C. (70° F.) in order to determine the uniformity of the molded material.

Five specimens shall be punctured after heating for one hour in an oven heated to 10° C. (18° F.) below the distortion point of the material as determined under Part (*C*), Sections 18 to 21. Puncture tests shall be made at this temperature with a permissible variation of ±5 per cent in degrees Centigrade. This test is intended to cover all molded materials which do not stand working temperatures above 125° C. (257° F.). Tests on materials which resist very high temperatures may be made above 125° C. (257° F.) when required.

Five specimens shall be punctured after they have had the rim immersed in melted paraffin for a depth of 1 in. and been entirely immersed in distilled water for 48 hours at normal room temperature of about 21° C. (70° F.). The surface of the specimen shall be wiped off with a dry cloth to remove all trace of excessive surface moisture and the puncture test shall be made in oil when necessary and at normal room temperature.

Report. 17. The results of tests shall be reported in the following order:

(*a*) The thickness of each specimen measured by micrometer in the direction perpendicular to its bottom surface, regardless of the path taken by the discharge. The thickness of all specimens shall be given in millimeters or mils.

(*b*) The puncture voltage of each test specimen and the average volts per millimeter or per mil as calculated from the average thickness of the specimens. Also give the maximum and minimum volts per millimeter or per mil.

(*c*) State the general character of the material tested with regard to leakage, if any is observed, and give the puncture voltage in volts per unit of thickness withstood by the bottom section whenever puncture takes place on the side of the specimen. This indicates the dielectric strength under both favorable and unfavorable conditions of molding. Experience shows that very plastic materials which flow easily when hot always puncture through the bottom, while materials which do not flow readily will often puncture through the side walls of a specimen at some distance up from the bottom.

(*d*) Report the frequency of the electrical circuit from which the test voltage is obtained.

(*C*) *Thermal.*

DISTORTION UNDER HEAT.

Specimen. 18. The same test specimen shall be used for this test as required for the transverse strength test, Section 10, molded from a hard steel mold ground to the dimensions given in Fig. 3.

Apparatus. 19. A special apparatus shall be used for this test as shown in Fig. 5. The specimen is supported on steel supports 100 mm. (3.94 in.) apart with the load applied on top of the specimen vertically and midway between the supports, the same as for the transverse test. The machine shall be arranged to apply two different loads, 2.5 kg. (5.512 lb.) and 5 kg. (11.023 lb.). The specimen shall be placed in an air bath surrounded by an oil bath which is so arranged that its temperature may be raised gradually. The machine shall be so arranged that the deflection of the specimen at its center between the supports can be measured on a scale in millimeters or mils and shall be equipped with a thermometer so that the temperature of the specimen can be recorded at any time. The machine may be arranged to automatically shut off the heat and sound an alarm as soon as the required deflection is reached.

Method. 20. Three test specimens shall be tested in the condition in which they are received, starting at normal room temperature of 21° C. (70° F.) and increasing the temperature of the specimen gradually at the rate of approximately 1° C. every two minutes.

The distortion point shall be considered the temperature at which the specimen has deflected 0.254 mm. (10 mils) at the center between the supports.

Report. 21. The results of the test shall be reported in the following order:

(*a*) The distortion point in degrees Centigrade and also in degrees Fahrenheit;

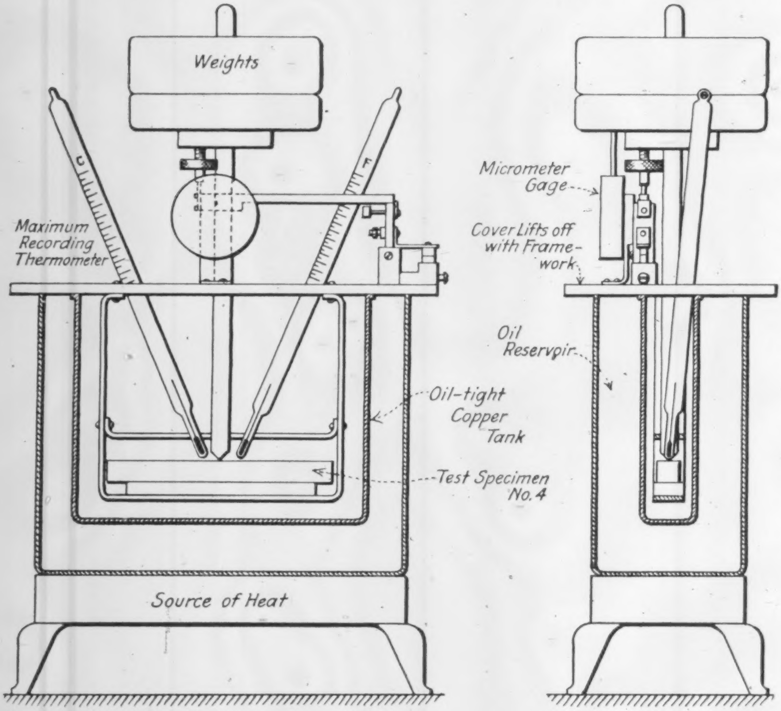

Weights
Maximum Recording Thermometer
C
F
Micrometer Gage
Cover Lifts off with Framework
Oil Reservoir
Oil-tight Copper Tank
Test Specimen No. 4
Source of Heat

FIG. 5.—Machine for Temperature Tests.

(*b*) The length of time required for the specimen to deflect 0.254 mm. (10 mils).

(*c*) State any peculiar characteristics of the material as noted either during the test or after the specimen is removed from the machine.

(*d*) Plot a curve for each test specimen showing the time

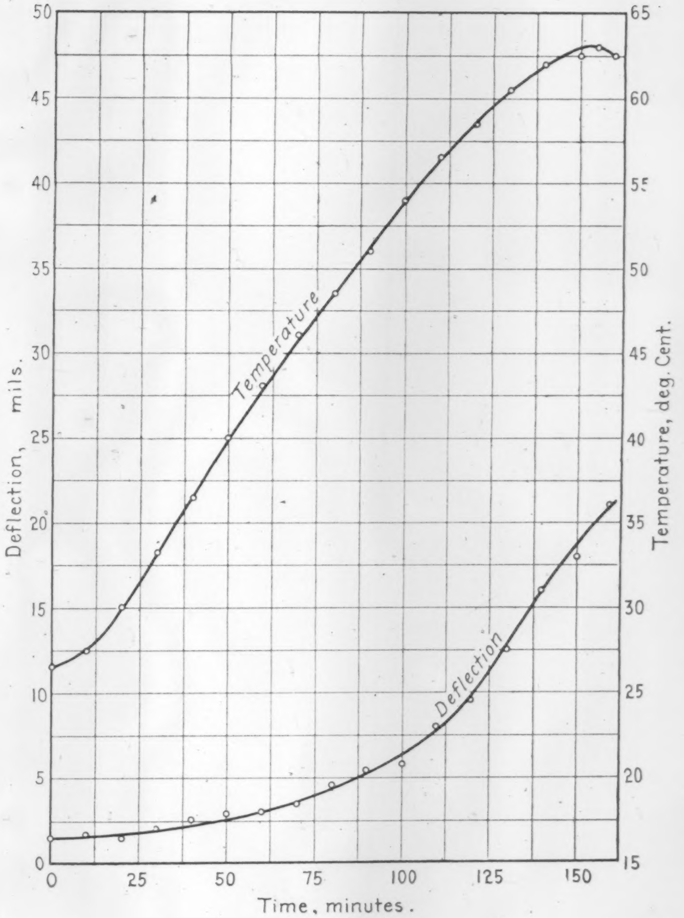


FIG 6.—Typical Curve from Temperature Test.

in minutes horizontally and the amount of deflection and also the temperature at given intervals, using vertical ordinates as shown in Fig. 6.

(*D*) *Effect of Moisture.*

Specimen. 22. One-half of the standard test specimen shown in Fig. 1 shall be used for this test. This specimen shall be broken in half and all loose particles removed.

Apparatus. 23. Any good chemical balance may be used; also, a beaker of distilled water at normal room temperature of about 21° C. (70° F.), and an oven of any standard make, capable of maintaining a uniform temperature of 100° C. (212° F.), ± 5° C.

Method. 24. Weigh carefully three test specimens in the condition in which they are received. If the material softens readily at moderate temperatures, the specimens may be placed in a desiccator for 24 hours, or in an oven at a temperature of 50° C. (122° F.), ± 5° C., for 24 hours. For materials which do not soften readily the specimens shall be placed in an oven heated to 100° C. (212° F.), ± 5° C., for 24 hours. After drying, the specimens shall be weighed again at normal room temperature. Place the specimens in distilled water, wholly immersed, for 100 hours at normal room temperature. Remove the specimens at the end of 100 hours, wipe off all surface water with a dry cloth and weigh carefully.

Report. 25. The results of the test shall be reported in the following order:

(*a*) The original weight of each specimen;

(*b*) The dry weight of each specimen;

(*c*) The saturated weight in grams of each specimen after immersion for 100 hours;

(*d*) The percentage of moisture contained in each test specimen as received, and the percentage of moisture absorbed during 100 hours, taking the dry weight as 100 per cent. Give the average for the three specimens.

AMERICAN SOCIETY FOR TESTING MATERIALS
PHILADELPHIA, PA., U. S. A.
AFFILIATED WITH THE
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE GENERAL METHODS FOR TESTING COTTON FABRICS.[1]

Serial Designation: D 39 - 19 T.

These methods are issued under the fixed designation D 39; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1915; REVISED, 1916, 1918, 1919.

1. The following General Methods are intended to be applicable for testing cotton fabrics. Where a material requires special treatment, specific methods will be described as they are developed for that material and such special tests shall have precedence over the general method.

I. CONDITION.

Dry Condition

2. The dry condition of cotton fabric shall be understood to be absolute dryness obtained by material placed in a ventilated drying oven maintained at a temperature of 105 to 110° C. (221 to 230° F.) and dried to constant weight as determined by two consecutive weighings without removal

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1920, to Mr. G. B. Haven, Chairman of Committee D-13 on Textile Materials, Massachusetts Institute of Technology, Cambridge, Mass.

from the oven, to be taken not less than ten minutes apart, and to show a further loss of not more than 0.1 per cent of the previous weighing.

Standard Condition.

3. The standard condition of cotton fabric shall be understood to be the condition in which it contains 6.5 per cent of its dry weight of moisture.

II. TEST METHODS.

(*A*) *Length.*

Length.

4. The length of a roll or piece shall be determined by running the cloth over a measuring drum of known circumference, from which the yardage is registered by a dial or counter driven by a chain or other positive or non-slip mechanism. Just enough uniform tension[1] is to be used on the cloth to keep it running flat and true.

(*B*) *Width.*

Width.

5. (*a*) The width of a roll or piece shall be determined at five different places uniformly distributed along the full length of the roll or piece, and may be determined at the same time as the total length.

(*b*) The average of the five measurements shall be the width.

(*C*) *Weight.*

Normal Weight.

6. (*a*) *Preferred Method.*—The net weight of the roll or piece from which covering and binding have been removed shall be determined. The net weight of the roll or piece divided by its superficial area in square yards shall be taken as the normal net weight per square yard.

(*b*) *Alternative Method.*—Three samples of known area, to contain not less than 4 sq. in. each, shall be stamped (preferably cut with a steel die) from one end of the roll or piece and quickly weighed. The normal square yard weight shall be computed from the average weight of these three samples.

Dry Weight.

7. (*a*) *Preferred Method.*—For the determination of dry weight two test specimens of approximately equal area, each

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[1] It has been suggested that a uniform tension of 2.5 times the weight of five running yards of the fabric will be sufficient to keep the fabric flat and preserve a proper relation for comparison of different fabrics. Invitation is extended to report to the committee the results of such tests upon different fabrics.

not less than 4 in. in length and of the entire width of the fabric, shall be cut one from each end of the roll or piece. The one from the outside end of the roll shall be taken as soon as the wrapping is removed and the one from the inner end of the roll as soon as the inner end of the roll has been reached in running the roll. The two samples shall be taken as soon as possible. These samples shall be placed in a dry air-tight container, the weight of which has been previously determined, and carefully weighed therein and then removed (check weight being made on container), the net weight calculated and the sample dried to constant weight in manner described in Section 2. The difference between the original weight of sample and the dry weight is the loss of moisture which when computed as percentage of the dry weight is the percentage regain of the material. The dry weight per square yard is then obtained from the normal weight per square yard as obtained in Section 6 (*a*), as follows:

$$\frac{\text{Normal weight per sq. yd.} \times 100}{100 + \text{percentage regain}} = \text{Dry weight per square yard.}$$

(*b*) *Alternative Method.*—From one end of the roll or piece five specimens, each 3 by 4.32 in., representing 0.01 sq. yd., shall be stamped (preferably cut with a steel die). Two specimens shall be cut near the selvages, one at the center, and the other two between the selvages and the center. These five specimens, with a total area equal to 0.05 sq. yd., shall be placed in the wire basket of a ventilated drying oven. The basket shall be so constructed with partitions, not less than ¼ in. apart, that the specimens may stand on edge. The specimens shall then be dried to bone dryness as described in Section 2. The combined weight of these specimens after drying represents the dry weight of 0.05 sq. yd. of the fabric, and the dry weight per square yard of the roll or piece is obtained by multiplying the above quantity by 20.

Retest. 8. If by the first tests the fabric fails to meet the specifications a second swatch shall be taken as follows: If the roll or piece is a complete warp, the second swatch shall be cut from the center of the roll or piece. If the roll or piece is a part warp, the second swatch shall be taken not less than 1½ yd. from the other end.

Moisture Content and Regain.

9. The difference between the normal weight of the fabric, Section 6, and the dry weight, Section 7, is the amount of moisture present.

(*a*) When computed as percentage of the normal weight this is the *Moisture Content* of the material.

(*b*) When computed as percentage of the dry weight, this is the *Moisture Regain* of the material.

(*D*) *Number of Threads per Inch.*

Number of Threads per Inch.

10. (*a*) The number of threads per inch or count of the fabric shall be determined by counting a space of not less than 1 in. in at least five different places in the roll or piece.

(*b*) The average of the five determinations shall be the count.[1]

(*E*) *Thickness.*

Thickness.

11. (*a*) The thickness shall be measured by an automatic micrometer which presses upon at least 0.5 sq. in. of the fabric with a uniform constant pressure, and which is so mounted as to make measurements 6 in. from the selvage.

(*b*) At least ten measurements at different portions of the roll or piece shall be made, and the average shall be the thickness of the fabric.

(*F*) *Strength.*

Tensile Strength.

12. Tensile strength tests shall be made by one of the four methods described as follows in detail, and fabrics shall be tested by the method shown for the classification under which they fall. In each case the results shall be recorded separately for warp and filling.

For the determination of tensile strength a swatch of the length specified in Table I shall be cut the entire width of the cloth and test specimens shall be cut from this swatch according to the respective diagrams shown at the bottom of Table I.

Two methods of determining the tensile strength shall be recognized:

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[1] For tire fabric used for carcass building the number of threads per inch shall be determined by counting a space of 10 in. in at least five different places in the roll or piece, and the average of the five determinations shall be the count.

(*a*) *Strip Test* (*Fig. 1*).—Under this method a long narrow strip of the fabric shall be clamped at each end by the jaws of the testing machine and strained to the point of rupture. **Strip Test.**

(*b*) *Grab Test* (*Fig. 2*).—Under this method the testing machine jaws, each of definite width, shall be made to reach into the body of a rectangular piece of fabric and shall be clamped a definite distance apart. Care shall be taken that the same set of threads are embraced by both pairs of jaws. The specimen shall then be strained to the point of rupture. **Grab Test.**

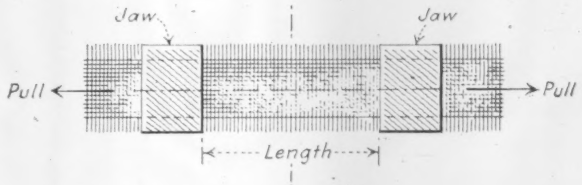


FIG. 1.—Illustration of Strip Test.

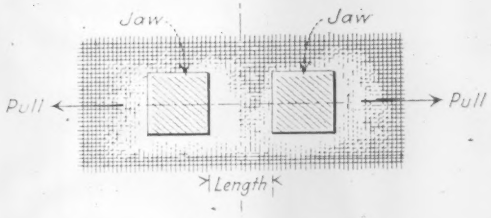


FIG. 2.—Illustration of Grab Test.

13. *Correction for Standard Moisture Regain.*—When it is desired to test tension specimens in the natural state in which they are cut from the roll or piece, the following method shall be employed to reduce the tensile strength found to the common basis of an assumed Standard Moisture Regain equal to 6.5 per cent of the bone-dry weight: **Correction for Moisture.**

(*a*) After preparing the specimens for the testing machine, those cut from the warp and those from the filling shall be weighed each in a separate batch under the natural moisture conditions which obtain at the time in the testing room.

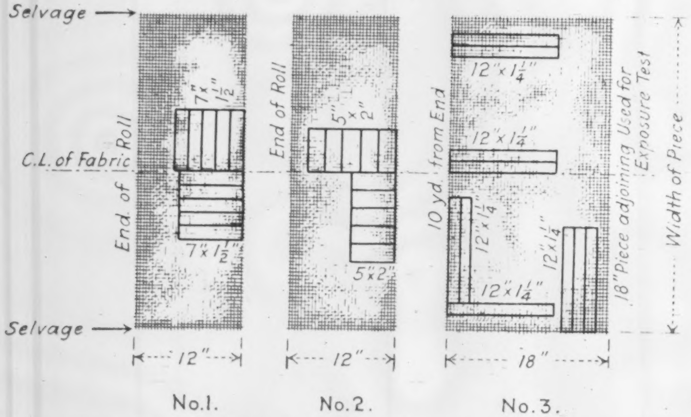
(*b*) The specimens shall then be tested immediately, in as rapid succession as possible, by the method specified in Table II.

(*c*) After rupture the broken specimens (entire) shall be placed in the basket of an oven and dried as defined in Section 2.

(*d*) The total warp and filling specimens shall be grouped each by themselves, forming two batches. The aggregate dry weight of the warp and filling specimens shall thus be obtained and the Moisture Regain at the time of the test determined.

TABLE I.—TENSILE STRENGTH TEST METHODS.

Method No.	1 Strip Method.	2 Grab Method.	3 Strip Method.	4 Single Strand.
Dimensions of specimens, in.	7 by 1 $\frac{1}{2}$	5 by 2	12 by 1 $\frac{1}{4}$	..
Width ravelled to — in.	1	..	1	..
Min. width of bottom or back jaws, in.	1 $\frac{1}{2}$	2	1 $\frac{1}{2}$	..
Width of top or front jaws, in.	1 $\frac{1}{2}$ (min.)	1	1 $\frac{1}{2}$ (min.)	..
Distance between jaws, in.	3	1	8	10
Speed of pulling jaw, in. per min.	20	12	12	12
Number of specimens each, warp and filling	5	5	5	20 strand


Selvage
Selvage
End of Roll
C.L. of Fabric
7" x 1 1/2"
7" x 1 1/2"
12"
End of Roll
5" x 2"
5" x 2"
12"
10 yd. from End
12" x 1 1/4"
12" x 1 1/4"
12" x 1 1/4"
12" x 1 1/4"
12" x 1 1/4"
18"
18" Piece adjoining Used for Exposure Test
Width of Piece
No. 1.
No. 2.
No. 3.

NOTES.—1. When material is less than 24 in. wide, the swatch shall be cut 24 in. long and the test specimens shall be laid out in such a manner that no part of any specimen shall come within 2 in. of either selvage.

2. When the specified number of threads or picks per inch is in fraction, the number of threads broken shall include the fraction as a full thread.

(*e*) The following formula shall then be applied, based upon the assumption that the Standard Moisture Regain of

TABLE II.—TENSILE STRENGTH. TEST METHOD CLASSIFICATION.

Name of Fabric.	Test Method No.	Humidity Conditions.
Tire Fabrics, including		
Carcass building fabric	1	Test specimens shall be tested in a dry condition as defined in Section 2. They shall be taken one at a time from the drying oven and broken in the testing machine within 30 seconds from the time of removal from the oven.
Chafing strip	1	
Breaker strip	1	
Cord fabric	4	
Ducks, including		
Hose duck	2	**(a) Specimens may be broken in dry condition as specified above for tire fabrics, such tests to be captioned, "Tested Bone Dry."** **(b) Specimens may be tested in their natural condition as taken from the roll or piece and corrected for the moisture present by the method of Section 12, such tests to be captioned. "Corrected for Standard Moisture Regain."**
Belt duck	2	
Tent duck	2	
Army duck	2	
Enamelling duck	2	
Sail duck	2	
Numbered duck	2	
Drills	2	
Sheetings	2	
Osnaburg	2	
Coutils	2	
Balloon Cloth[1]	1	
Wing Fabric[2]	3	**Exposed before testing for at least two hours in an atmosphere of 65 per cent relative humidity and 70° F. and tested in this atmosphere.**

[1] Balloon cloth shall be tested on machine of the inclination balance type with maximum capacity of 400 lb.

[2] The elongation of wing fabric shall be observed for each specimen when subjected to loads of 10 lb., 20 lb., and 70 lb. Wherever possible autographic records shall be taken.

NOTE.—Fabrics not included in the above list will be given a test method classification by Committee D-13 on application of those interested.

manufactured cotton is 6.5 per cent of the dry weight, that the Actual Percentage Regain is between the limits of 3 and 6.5 per cent of the dry weight, and that for 1 per cent of moisture regain there is an increase of 6 per cent in the tensile strength of the fabric.

$$\begin{array}{c}\text{Tensile Strength corrected}\\ \text{to Standard Moisture Regain}\end{array} = \frac{(\text{Tensile Strength from machine reading}) \times 139}{100 + (6 \times \text{Actual Percentage Regain})}$$

Example.—A specimen of fabric broken under natural conditions gave a tensile strength of 294 lb. as read from the machine dial. By weighing before and after drying the specimen was found to contain a Moisture Regain equal to 3 per cent of the bone-dry weight. The tensile strength corrected to a common basis of 6.5 per cent Moisture Regain would therefore be

$$\text{Tensile Strength corrected} = \frac{294 \times 139}{100 + (6 \times 3)} = 346 \text{ lb.}$$

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INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE METHOD
FOR
DETERMINATION OF FUSIBILITY OF COAL ASH.[1]

Serial Designation: D 22 – 19 T.

This method is issued under the fixed designation D 22; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

APPARATUS.

Standard Furnace.—The No. 3 melter's furnace of the American Gas Furnace Co., shall be used, or its equivalent.

The No. 3 melter's furnace is a type of pot furnace especially suitable for fusion determination in that the burners, three in number, are on a tangent near the base of the furnace, thus producing a rotary flame which completely surrounds the crucible in which the cones are placed. The whirling flame heats the crucible uniformly and when the furnace is operated with excess gas supply, a reducing atmosphere is maintained within the crucible, which condition gives the lowest point at which the ash fuses. The air should be supplied at an approximate pressure of 3 lb. per sq. in., and either natural or artificial gas may be used.

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[1] Criticisms of this Tentative Method are solicited and should be directed, preferably before January 1, 1920, to Mr. S. W. Parr, Chairman of Committee D-3 on Methods of Sampling and Analysis of Coal, University of Illinois, Urbana, Ill.

This method, when adopted as standard, will be added to the present Standard Methods for Laboratory Sampling and Analysis of Coal (Serial Designation: D 22–16), 1918 Book of A.S.T.M. Standards.

The furnace proper consists of three easily replaceable fire-clay parts, namely, a lower cylinder containing the three tangential tuyeres, and forming the bottom of the furnace, a removable upper cylinder 7 in. in internal diameter and 7 in. high, and a cover plate $1\frac{1}{2}$ in. thick, having a vent hole in the center for the flue gas.

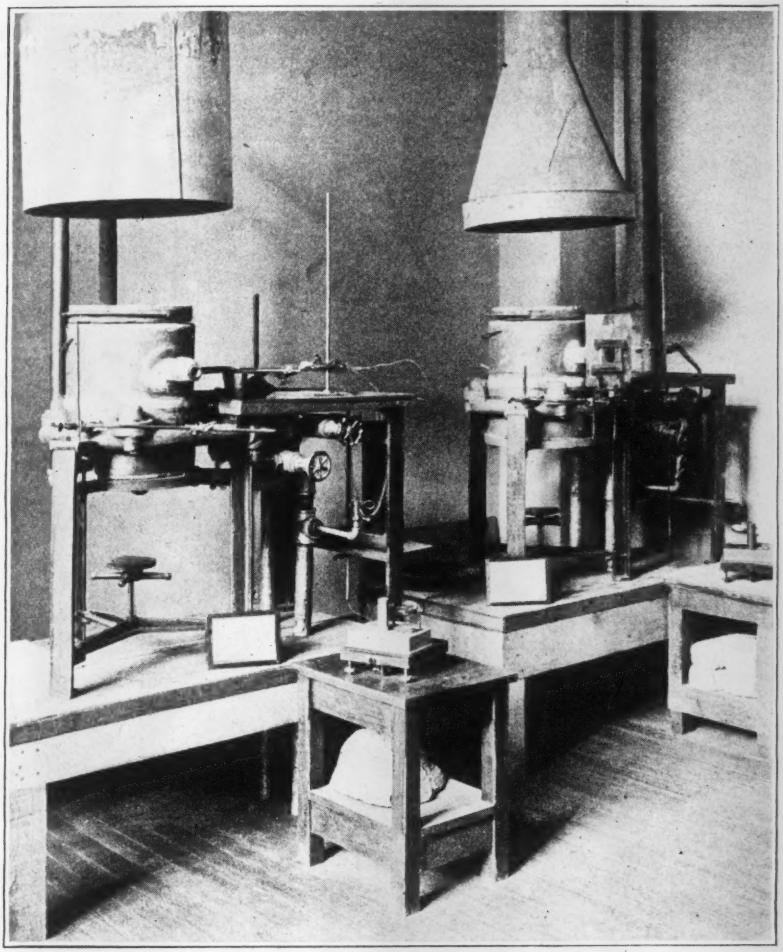

FIG. 1.—No. 3 Melter's Furnace and Accessories.

The stock design should be modified by furnishing the upper cylinder with two holes in the side: a 2-in. observation hole with its center 4 in. from the top of the cylinder (excluding cover plate), and a 1-in. thermocouple hole 90 deg. to the right of the observation hole; the bottom of these two holes being in the same horizontal plane. The interior of the furnace is cylindrical and approximately 7 in. in diameter and 11 in. high.

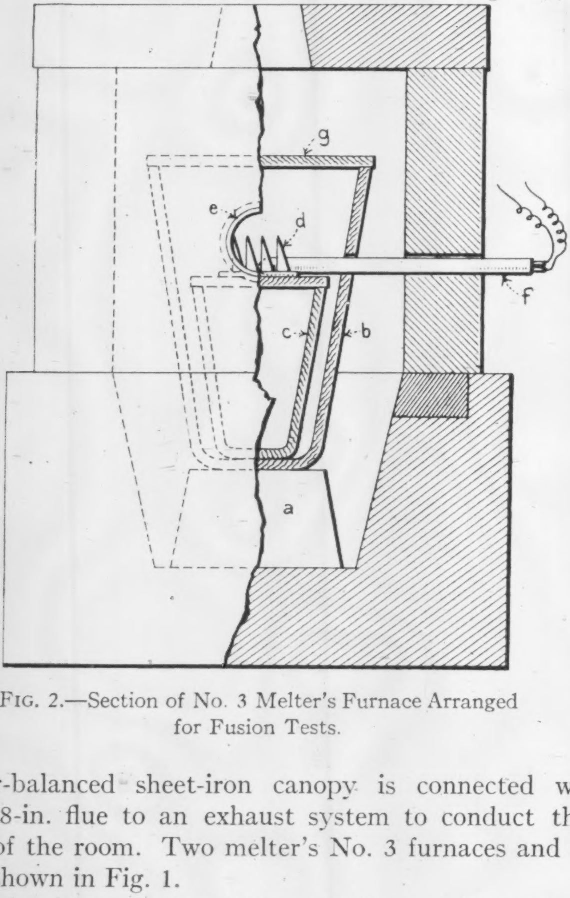

FIG. 2.—Section of No. 3 Melter's Furnace Arranged for Fusion Tests.

A counter-balanced sheet-iron canopy is connected with a telescopic 8-in. flue to an exhaust system to conduct the hot gases out of the room. Two melter's No. 3 furnaces and accessories are shown in Fig. 1.

The joint between the upper and lower cylinder is made fairly gas-tight by spreading on the top of the lower cylinder a thick paste of alundum cement to a depth of $\frac{1}{2}$ in. and then firmly pressing the upper cylinder into place. The outer part of the joint is also smoothed over with alundum cement. The fire-clay furnace cylinders and cover will withstand a temperature of about 1650° C.

Refractory Crucibles.—The interior of the furnace as arranged for making a test is shown in Fig. 2. The ash cones *d* are supported on a plate of alundum cement serving as a cover for crucible *c* which is a Denver fire-clay hard burned crucible, No. E, 4½ in. high and 3 in. in diameter at the top. The cone-supporting crucible is within the crucible *b* which with the cover *g* serves as a muffle. Crucible *b* is a Denver fire-clay hard burned crucible, No. K, 7¼ in. high and 4⅝ in. in diameter at the top, and rests on fire-clay support *a*. This crucible should be provided with two holes in the side, an observation hole 1¾ in. in diameter with its center 2 in. from the top of the crucible and a thermocouple hole 1 in. in diameter, 90 deg. to the right of the observation hole. The bottom of this hole should be in the same horizontal plane as the bottom of the observation hole. The hard burned fire-clay crucibles will not withstand a temperature exceeding 1500° C. The average life of a fire-clay crucible under these conditions is about six runs.

Corundite crucibles and covers of the Massillon Stone and Fire Brick Co. are longer lived than the fire-clay crucibles, being good for about fifty runs. A special form used by the Bureau of Mines is 3 in. inside diameter, 4½ in. high outside, with a wall thickness of about ½ in. Crucibles should be provided with two holes in the side, an observation hole 2 in. in diameter with its center 1¾ in. above the bottom of the crucible, and a thermocouple hole 1 in. in diameter, 90 deg. to the right of the observation hole. The bottom of this hole should be in the same horizontal plane as the bottom of the observation hole.

Observation Tube.—A fused silica or refractory porcelain tube *f*, 1⅞ in. in external diameter and 6 in. long, is placed in the 2 in. observation hole of the furnace, the inner end being flush with the inside furnace wall and the other end projecting out of the furnace. A brass sleeve carrying a thin glass window is slipped on the outer end of the observation tube to prevent the escape of burning gas, which would interfere with a convenient observation of the cones.

Blowing Tube.—At furnace temperatures above 1000° C., it is very difficult to observe the ash cones. A Marquadt, Usalite, Impervite or equal quality porcelain blowing tube $\frac{1}{4}$ in. in diameter is inserted through the same hole as the thermocouple tube. This tube has small perforations along one side by which air may be forced upon the cones at the time of making the observation, thus momentarily cooling the ash cones and rendering them visible. The blowing tube is connected to the compressed air line by means of rubber tubing and the air is let into the tube at the time of observation by means of a pinchcock.

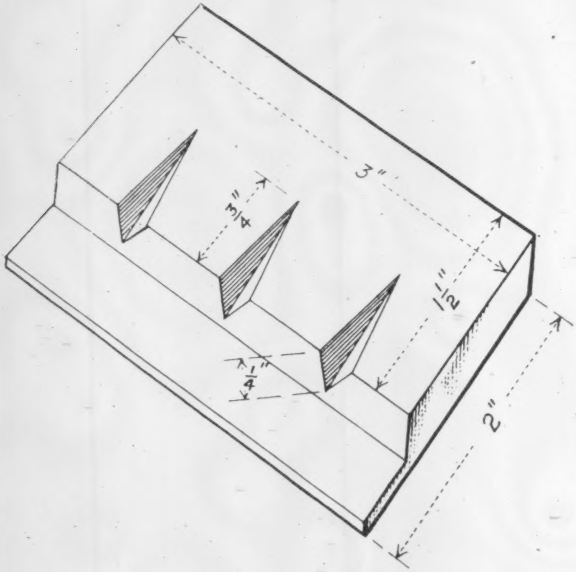

FIG. 3.—Brass Cone Mold.

Brass Cone Mold.—A brass cone mold for making ash cones, $\frac{3}{4}$ in. high and $\frac{1}{4}$ in. at each side of base, which is an equilateral triangle, is illustrated in Fig. 3.

Pyrometer.—Temperature measurements may be made with a thermocouple of platinum and platinum-rhodium, protected from the furnace gases by a glazed Marquadt, Usalite, Impervite or equal quality porcelain tube and a high-resistance millivoltmeter; or with an optical pyrometer preferably of the

Leeds and Northrup, or Wanner type. This equipment should be checked frequently by mounting small pieces of pure gold or nickel wire or foil in the same manner as the cones. With a strong reducing atmosphere 1452° C. should be obtained for the melting point of the nickel and 1063° C. for the gold. The pyrometer equipment should also from time to time be standardized through the temperature range for which it is used, by a suitably equipped standardizing laboratory such as that of the United States Bureau of Standards.

PREPARATION OF COAL ASH.

Spread out 50 to 100 g. of 60-mesh coal on a 6-in. fire-clay roasting dish, and completely convert to ash in a muffle furnace at a temperature of 800 to 900° C. Transfer 5 to 10 g. of this ash to an agate mortar[1] and grind to a fineness of 200 mesh. Then place the ash in a silica or porcelain capsule, $\frac{5}{8}$ in. deep and $1\frac{3}{4}$ in. in diameter, and ignite for a period of two hours in a current of oxygen, at a temperature of 800 to 850° C. This ignition is made to insure complete and uniform oxidation of the ash.

PREPARATION OF CONES.

Moisten the ignited ash with a 10-per-cent dextrin solution and work into a plastic mass with a spatula. Mold the plastic material into small triangular pyramids $\frac{3}{4}$ in. high and $\frac{1}{4}$ in. wide at the side of the base. The pyramids are made by firmly pressing the plastic material with a steel spatula into a brass mold of the dimensions mentioned, the mold being similar to that shown in Fig. 3. Strike off the surface smooth and remove the cone from the mold by applying a small knife blade at the base. Mount the cones when dry in a refractory base composed of a mixture of equal parts of kaolin and calcined alumina. Moisten the base mixture to make it workable, and spread a part of it out on a sheet-iron plate. Then mount the cone in a vertical position in a small hole made in the base, and put base material into the hole around the bottom of the cone to fill the crevices and make the cone stand firmly. Usually five cones are mounted in one base in the manner shown in Fig. 4. Dry the sheet-iron plate with the test piece on a hot plate. Ignite the cones at a dull red heat for 30 minutes in an open muffle to remove the carbonaceous material.

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[1] A mechanical agate-mortar grinder will save time where many determinations are made.

METHOD OF HEATING.

Place the test piece in the muffle crucible of the melter's furnace in the position shown in Fig. 2, place the loosely fitting cover *g* on the crucible, and ignite the gas. It is necessary to let the gas burn about 10 minutes to heat the furnace parts before the large cover plate of the furnace is replaced; otherwise the flame is apt to blow out. During this time increase the flow of gas and air sufficiently to cause the combustion to take place just above the tuyeres and yet maintain a yellowish flame at least 6 in. above the opening in the furnace cover plate. While such a flame is maintained above the furnace gradually increase the temperature by a suitable adjustment of gas and air to 800° C., then reduce the rate of heat increase to not less than 5° C. and not more than 10° C. per minute. Maintain this rate until the end of the test. It is also important that the 6 in. reducing flame be maintained at the furnace vent throughout the test, if possible, and at all events up to a temperature of 1450° C. Temperatures above 1450° C. require larger proportions of air to gas; however, a strongly reducing atmosphere is not so essential at the higher temperatures, as refractory ashes, owing

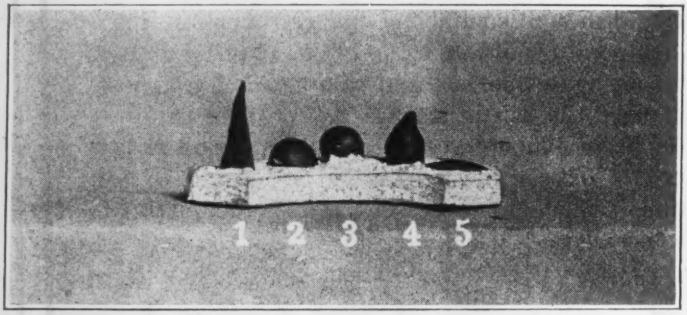

FIG. 4.—Typical Forms of Cones Fused in the No. 3 Melter's Furnace.

to their low iron-oxide content, are only slightly affected by oxidizing or reducing atmospheres. After a test has been completed, turn the supply of gas and air off gradually to avoid cracking the muffle crucible.

The softening temperature is defined as the temperature at which the cone has fused down to a spherical lump, as shown in cones 2 and 3 of Fig. 4. Cone 4 has almost reached the softening temperature.

The permissible differences of the softening temperature point in duplicate determinations are as follows:

Same analyst	30° C.
Different analysts	50° C.

NOTES.

Critical points other than the softening temperature, that may be observed during the test, and which may be of value are as follows:

The Initial Deformation Temperature.—The temperature at which the first rounding or bending of the apex of the cone takes place, as shown in cone 1 of Fig. 4. Such bending must not be confused with a shrinking or warping of the cone.

The Fluid Temperature.—The temperature at which the cone has spread out over the base in a flat layer, as represented by cone 5 of Fig. 4.

AMERICAN SOCIETY FOR TESTING MATERIALS
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INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE METHOD
FOR
DETERMINATION OF SOFTENING POINT OF TAR PRODUCTS.[1]

(CUBE-IN-WATER METHOD.)

Serial Designation: D 61 – 19 T.

This method is issued under the fixed designation D 61; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

1. (*a*) The softening of pitch takes place at no definite moment or temperature. As the temperature rises, pitch gradually and imperceptibly changes from a brittle or exceedingly thick and slow flowing material to a softer and less viscous liquid. For this reason the determination of the softening point must be made by a fixed, arbitrary and closely defined method if the results obtained are to be comparable.

(*b*) The methods herein described are not applicable to pitches having a melting point above 77° C. (170°.6 F.)

(*c*) For the purpose of shortening the time required for testing, hard pitches having a softening point between 43 and 77° C. (109.4 and 170°.6 F.) are cooled at 15°.5 C. (60° F.) instead of at 4° C. (39°.2 F.) as prescribed for soft pitches.

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[1] Criticisms of this Tentative Method are solicited and should be directed, preferably before January 1, 1920, to Mr. Prévost Hubbard, Secretary of Committee D 4 on Road Materials, 15 Maiden Lane, New York City.

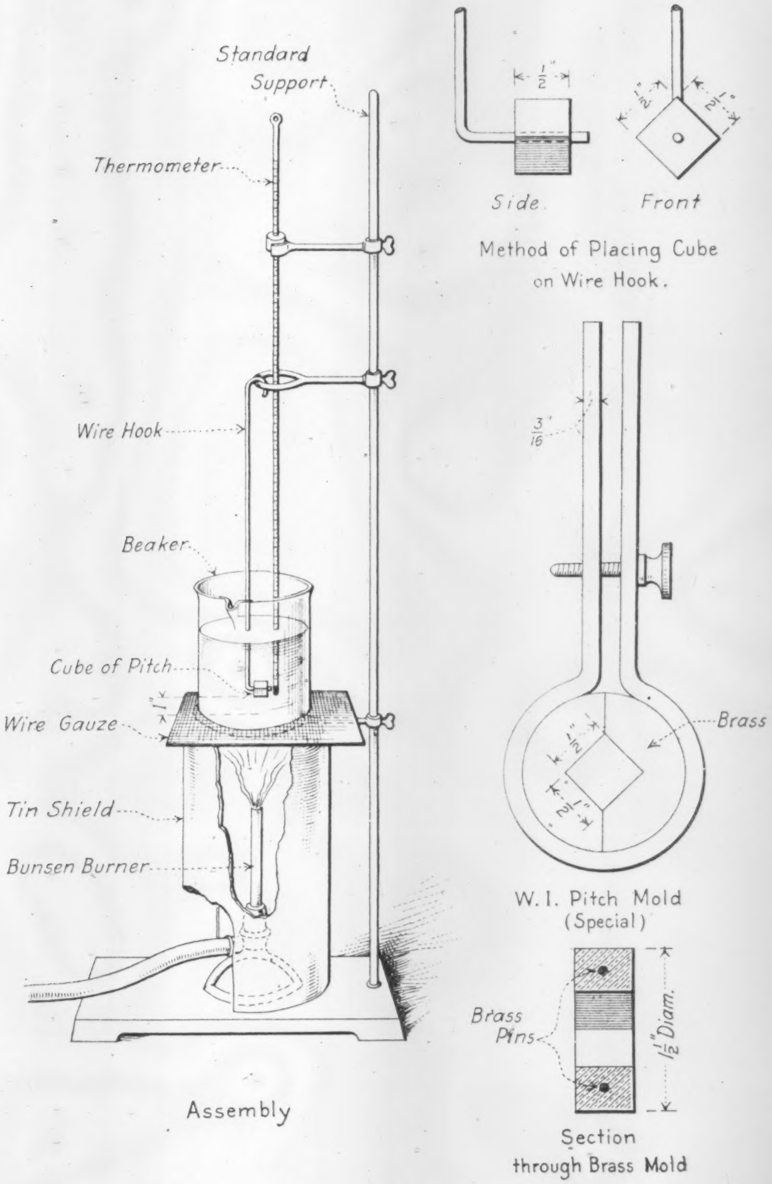
Standard Support
Thermometer
Wire Hook
Beaker
Cube of Pitch
1"
Wire Gauze
Tin Shield
Bunsen Burner
Assembly
1/2"
Side
1/2"
1/2"
Front
Method of Placing Cube on Wire Hook.
3/16"
1/2"
1/2"
Brass
W. I. Pitch Mold (Special)
Brass Pins
1 1/2" Diam.
Section through Brass Mold

FIG. 1.—Apparatus for Cube-in-Water Method.

I. APPARATUS.

2. The apparatus shall consist of the following:

Mold. (*a*) A mold suitable for forming a 12.7-mm. ($\frac{1}{2}$-in.) cube of pitch. (A recommended type is shown in Fig. 1.)

Hook. (*b*) An L-shaped right angled hook made of No. 12 B. & S. gage copper wire (diameter 2.05 mm. = 0.0808 in.) the foot of which shall be 2.54 cm. (1 in.) long. See Fig. 1.

Container. (*c*) A glass vessel, capable of being heated, not less than 11 cm. (4.33 in.) in diameter by 14 cm. (5.51 in.) deep. (A 600-cc. beaker, Griffin low form, meets this requirement.)

Thermometer. (*d*) A thermometer which shall conform to the following specifications:

Total length	370 – 400 mm.	(14.57 – 15.75 in.)
Diameter	6.5 – 7.5 "	(0.256 – 0.295 ")
Bulb length	Not over 14 "	(Not over 0.55 ")
Bulb diameter	4.5 – 5.5 "	(0.177 – 0.217 ")

The scale shall be engraved upon the stem of the thermometer, shall be clear cut and distinct, and shall run from 0 to 80° C. (32 to 176° F.) in $\frac{1}{5}$° C. divisions. It shall commence not less than 7.5 cm. (2.95 in.) above the bottom of the bulb. The thermometer shall be furnished with an expansion chamber at the top and have a ring for attaching tags. It shall be made of a suitable quality of glass and be so annealed as not to change its readings under conditions of use. It shall be correct to 0°.25 C. (0°.45 F.) as determined by comparison at full immersion with a similar thermometer calibrated at full immersion by the United States Bureau of Standards.

II. PREPARATION OF SAMPLE.

Preparation of Sample. 3. The pitch shall be formed into a 12.7-mm. ($\frac{1}{2}$-in.) cube, truly shaped and with sharp edges, either by melting and pouring, or softening and pressing, into a mold. In all cases an excess of pitch shall be used and the surplus material shall be cut off cleanly with a slightly heated knife. The harder pitches specified can ordinarily be molded at room temperature, the softer pitches in water at about 40° C. (39°.2 F.) If they are melted, they should first be thoroughly stirred, avoiding incorporating air bubbles in the mass, and then poured into the mold so as to leave an excess on cooling. The mold should rest on a brass plate and the surface of the plate and the interior surfaces of the mold should be amalgamated to prevent the pitch from adhering to them.

III. TESTING.

(*A*) *Pitches having Softening Points between 43 and 77° C. (109.4 and 170°.6 F.).*

4. Assemble the apparatus as shown in Fig. 1. Fill the glass vessel to a depth of substantially 9.5 cm. (3.75 in.) with freshly boiled, distilled water at 15°.5 C. (60° F.). Place the cube of pitch on the wire as shown in Fig. 1 and suspend it in the water so that its lower edge is exactly 2.54 cm. (1 in.) above the bottom of the glass vessel and its upper edge is 5.08 cm. (2 in.) below the surface of the water. Allow it to remain in the water for 15 minutes before applying heat. Suspend the thermometer so that the bottom of the bulb is level with the bottom edge of the cube of pitch and within 0.635 cm. ($\frac{1}{4}$ in.), but not touching, the cube. **Assembling.**

5. Apply the heat in such a manner that the temperature of the water is raised 5° C. (9° F.) each minute. **Heating.**

6. The temperature recorded by the thermometer at the instant the pitch touches the bottom of the glass vessel shall be reported as the softening point. **Softening Point.**

7. The rate of rise of temperature shall be uniform and shall not be averaged over the period of the test. The maximum permissible variation for any minute period after the first three shall be ±0°.5 C. (0°.9 F.). All tests in which the rate of rise in temperature exceeds these limits shall be rejected. **Permissible Variation in Rise of Temperature.**

(*B*) *Pitches having Softening Points below 43° C. (109°.4 F.).*

8. Use the same method as given under (*A*), except that the water when placed in the glass vessel shall be at a temperature of 4° C. (39°.2 F.). The cube shall be allowed to remain 15 minutes in this water before applying the heat. **Modification for Soft Pitches.**

IV. ACCURACY.

9. The limit of accuracy of the test is ±0°.5 C. (0°.9 F.). **Accuracy.**

V. PRECAUTIONS.

10. The use of freshly distilled water is essential, as otherwise air bubbles may form on the cube and retard its sinking. Rigid adherence to the prescribed rate of heating is absolutely essential in order to secure accuracy of results. **Precautions.**

A sheet of paper placed on the bottom of the glass vessel and conveniently weighted will prevent the pitch from sticking to the glass vessel, thereby saving considerable time and trouble in cleaning.

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TENTATIVE DEFINITIONS AND RULES
GOVERNING THE
PREPARATION OF MICROGRAPHS OF METALS AND ALLOYS.[1]

Serial Designation: E 2-19 T.

These definitions and rules are issued under the fixed designation E 2; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917; REVISED, 1918, 1919.

I. STANDARD MAGNIFICATIONS.

General Use. 1. The standard magnifications for general use in making micrographs, expressed in diameters, shall be as follows:

10, 25, 50, 75, 100, 200, 500, 1000.

2. For general use in Society reports, and for showing grain size, the following magnifications are recommended:

MATERIAL.	CAST.	WROUGHT.
Steel and Ferrous Materials	100	100
Copper	50 and 100	75
Copper-Zinc Alloys	50 " 100	75
Copper-Nickel Alloys	50 " 100	200
Copper-Nickel-Zinc Alloys	50 " 100	200
Lead-Tin-Antimony Alloys[2]	50 " 200	....

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[1] Criticisms of these Tentative Definitions and Rules are solicited and should be directed, preferably before January 1, 1920, to Mr. W. H. Bassett, Chairman of Committee E-4 on Magnification Scales for Micrographs, American Brass Co., Waterbury, Conn.

[2] Including those containing small percentages of copper.

Reproduction of Micrographs.

3. (*a*) Reproductions of micrographs in publications shall be made of exact standard magnifications except in those special cases where the details of structure are to be illustrated.

(*b*) If micrographs submitted for publication are not of standard magnification, they shall be enlarged or reduced to the nearest standard size. The actual magnification appearing in print shall be stated under the micrograph. See Paragraph (*d*).

(*c*) To facilitate the reproduction, authors should be advised that their micrographs should be of proper size to fit the printed page, and in order to conserve space that micrographs be printed in the form of squares.

(*d*) With each micrograph shall be printed an explanatory title, together with actual magnification, etching medium, treatment, etc., indicating what the author intends to show, so that it will not be necessary to search the text for general information. With micrographs at magnifications of approximately 500 diameters and above, the numerical aperature of the objective and the type of illuminator shall be given.

(*e*) Photographs in which the magnification is less than 10 diameters are usually made with photographic lenses or single magnifiers. These will be considered as "macrographs."

With each macrograph should be printed an explanatory title, together with the actual magnifications, method of illumination, and general treatment indicating what the author desires to illustrate, so that it will not be necessary to refer to the text for general information.

II. LENSES.

Lenses

4. For obtaining the magnifications recommended, the following types of lenses are suggested as suitable for general commercial work:

(*a*) For magnifications from 20 to 50: A lens of the microplanar or microtessar type (*e. g.*, approximately 35-mm. focal length); no ocular is required.

(*b*) For magnifications from 30 to 75: A 32-mm. objective with Huyghens ocular (approximately ×5).

(*c*) For magnifications from 75 to 150: A 16-mm. objective with Huyghens ocular (approximately ×5).

(*d*) For magnifications from 250 to 500: A 4-mm. objective (preferably apochromatic) with projection ocular.

Directions.

5. (*a*) All objectives should be corrected for uncovered objects.

(*b*) In using one of the lens combinations given above, the length of the camera bellows may be adjusted to give the exact magnification desired.

It should be borne in mind, however, that increasing the magnification by increasing the length of the camera bellows adds nothing to the detail of the micrograph. This depends mainly upon the resolving power of the objective used.

(*c*) The magnification shall be determined by accurately measuring the image of a stage micrometer scale, and not by estimation from lens combinations, or microscope or camera adjustments.

III. GRAIN SIZE.

Definition of Grain.

6. (*a*) *Alloys Consisting of but One Type of Crystals* (*e. g.*, copper, alpha brass, etc.): In counting individual grains the original crystal, including the twinned layers, shall be called one grain.

(*b*) *Alloys Consisting of Two Metallographic Components* (*e. g.*, steels, Muntz metal, etc.): The original grain which has given rise to the aggregation of the two components shall be taken as the unit when determinable and the individual component in other cases.[1] When grain size is included in actual specifications, the term should always be defined in such specifications.

Method of Measurement of Grain Size.

7. For measuring grain size, two methods are recommended depending upon the condition of the material:

(*a*) *For Material in which the Grains are Equi-axed* (*e. g.*, most metals in the cast and in the annealed state): The planimetric method as modified by Jeffries[2] is recommended for use as being very accurate and rapid. It is recommended that the circular area used should always include at least 50 grains.

(*b*) *When the Grains are not Equi-axed* (*e. g.*, in strained materials): Heyn's intercept method should be used, the average grain size being determined by counting the number of grains at a given magnification along a line of known length on two axes at right angles to each other, one axis being parallel to the direction of rolling. In some cases a third count along a line perpendicular to the other two may be desirable. This will necessitate the preparation of another polished surface.

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[1] See U. S. Navy Specifications, 49-S-2-c, p. 7.

[2] See Note on pp. 771–773.

Numerical Expression of Grain Size.

8. The grain size as determined by the planimetric method, Section 7 (*a*), should be expressed as the number of grains per unit area (square inch or square centimeter). This may also, but less preferably so, be expressed as the average grain area; or the average linear dimension of the grain may be given. The grain size as determined by the intercept method, Section 7 (*b*), should be expressed by giving the average number of grains per linear unit in the two directions; or the average number per unit area together with the ratio of length to breadth of grain (L/B) may be given.

Use of Grain Size in Specifications.

9. If grain size is to be included in specifications, it should be expressed as the maximum or minimum allowable as determined above. It is recommended that only in extreme cases should grain size be made the sole basis of rejection of material.

NOTE

JEFFRIES' METHOD FOR GRAIN-SIZE MEASUREMENTS.[1]

A circle 79.8 mm. in diameter is drawn on the rough side of a ground-glass screen, the center of the circle being near the center of the rectangular section of the screen. This ground glass is mounted in a frame which fits a metallographic camera, the smooth side of the glass being on the outside. When the image of the specimen for grain-size determination is focused on the screen, the circle will be plainly visible and its circumference should be well within the image.

When the image is properly focused the grains intersected by the circumference of the circle are checked and counted. Since the check marks must be made on the smooth side of the glass, a soft red pencil, such as is used in laboratories for marking beakers and flasks, will be found satisfactory. The marks used to indicate the boundary grains are usually short, straight lines intersecting the circumference of the circle and perpendicular to it. The completely included grains are next checked and counted, after which the red marks are erased from the glass with a dry cloth. The specimen can then be moved and other measurements made as desired.

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[1] This method has been condensed from the paper by Mr. Zay Jeffries appearing in *Metallurgical and Chemical Engineering*, Vol. XVIII, p. 185 (1918).

One-half the number of grains intersected by the circumference of the circle, added to the number of completely included grains, gives the number of equivalent whole grains within the circle. If the equivalent number of whole grains within the circle measured at a certain magnification be multiplied by the number in the third column of Table I opposite the magnification used, the product will be the number of grains per square millimeter.

TABLE I.

Magnification Used (= m).	Diameter of Circle, mm.	Multiplier to Obtain Grains per Square Millimeter (= f).
Full size	79.8	0.0002
10	"	0.02
25	"	0.125
50	"	0.5
75[a]	"	1.125
100	"	2.0
150	"	4.5
200	"	8.0
250	"	12.5
300	"	18.0
500	"	50.0
750	"	112.5
1000	"	200.0
1500	"	450.0
2000	"	800.0

[a] At 75 diameters, if a circle 84.5 mm. in diameter, or a rectangle having an area of 5625 sq. mm. is used, the factor f becomes unity.

A circle 79.8 mm. diameter has an area of 5000 sq. mm. If it is desired to use a rectangle of the same area in place of a circle for the determination, convenient sizes are given as follows:

70.7 by 70.7 mm.
65 " 77 "
60 " 83.3 "
55 " 91 "
50 " 100 "

Since each of these rectangles has an area of about 5000 sq. mm., the multipliers given in Table I can be used for any one of them, or any other rectangle having an area of 5000 sq. mm. To make a grain-size determination with a rectangular in place of a circular area, the grains intersected by the periphery of the rectangle should be counted, one-half the number added to the completely included grains and the result will be the number of equivalent whole grains within the rectangle. If the determination is made at one of the magnifications given in Table I, the number of grains per square millimeter can be obtained by multiplying the equivalent number of whole grains within the area by the multiplier (f) opposite the magnification used. The rectangle could be used on a ground glass as described above for the circle, or it could be used on a micrograph.

Some metallographists prefer to refer to the grain size in terms of the diameter of the average grain in millimeters, or the area of the average grain in μ^2. The following simple formulas will be found helpful in these cases:

w = number of boundary grains;
z = number of completely included grains;
x = equivalent number of whole grains in 5000 sq. mm. (circle 79.8 mm. in diameter or rectangle having area of 5000 sq. mm.);
m = magnification used;
f = multiplier to obtain number of grains per square millimeter;
n = number of grains per square millimeter;
d = diameter of average grain in millimeters;
a = area of average grain in μ^2.

$$x = \tfrac{1}{2} w + z$$

$$f = \frac{m^2}{5000}$$

$$n = fx$$

$$d = \frac{1}{\sqrt{n}}$$

$$a = \frac{1{,}000{,}000}{n}$$

After considering various criticisms, owing to the fact that 75 diameters has become an established practice for use in illustrating the structure and grain size of wrought copper and the copper-zinc alloys, and that a large volume of work has been done using this magnification, it seems advisable to retain a magnification of 75 diameters for this class of material.

TENTATIVE REVISIONS
OF
A.S.T.M. STANDARDS

Tentative Revisions of A.S.T.M. Standards are printed for one or more years with a view of eliciting criticisms, of which the committee concerned will take due cognizance before recommending final action.

Members of the Society and others are invited to direct written criticisms of any of these Tentative Revisions to the officer of the appropriate committee, whose name and address appear in the footnote in connection with each revision.

TENTATIVE REVISION

OF

STANDARD SPECIFICATIONS FOR OPEN-HEARTH STEEL GIRDER AND HIGH TEE RAILS.

(Serial Designation: A 2–12).[1]

Omit Sections 7 to 10, inclusive, and substitute the following Sections 7 to 9, renumbering the remaining sections of the specifications:

Impression Test Specimens.

7. (*a*) Four representative sections of rail from each melt shall be selected by the inspector as test specimens.

(*b*) Excess scale on the head of the section shall be carefully removed.

Impression Test.

8. (*a*) The head of each specimen shall be subjected to a pressure of 50 net tons (100,000 lb.) for a period of 15 seconds, applied through a ball $\frac{3}{4}$ in. in diameter.

(*b*) The average depth of impression obtained on the four specimens shall not be more than 3.8 mm. for Class A rails, nor more than 3.6 mm. for Class B rails.

Retests.

9. If the average of the impression tests from any melt fails to conform to the requirements specified in Section 8 (*b*), the manufacturer may at his option test each rail from such melt by making an impression test on the web, as described in Section 8 (*a*). Rails so tested which conform to the requirements as to depth of impression specified in Section 8 (*b*) shall be accepted.

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[1] 1918 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. C. L. Warwick, Secretary, Committee A-1 on Steel, 1315 Spruce Street, Philadelphia, Pa.

TENTATIVE REVISION

OF

STANDARD SPECIFICATIONS FOR ENGINE-BOLT IRON.

(SERIAL DESIGNATION: A 40–18).[1]

Revise Section 1 by inserting the words "all pig" before the word "puddled," making the section read as follows:

> The iron shall be made from all pig puddled iron and shall be free from any admixture of iron scrap or steel.

TENTATIVE REVISION

OF

STANDARD SPECIFICATIONS FOR 2⅝-IN. COTTON RUBBER-LINED FIRE HOSE FOR PRIVATE DEPARTMENT USE.

(SERIAL DESIGNATION: D 14–15).[2]

1. *Section 1* (*b*).—Eliminate the first two sentences and revise the third sentence by omitting words in brackets and adding words in italics, so that the section will read as follows:

> "(*b*) Sizing or other treatment liable to cause mildew shall [be avoided] *not be used*."

2. *Section 2* (*e*).—Change to read as follows by the omission of words in brackets and the addition of words in italics:

> "(*e*) The lining (without cement [and] *or* backing) shall be made up of not less than three calendered sheets, and shall be not less than [0.049] *0.050 nor more than 0.060* in. in thickness. [, and, including cement and other backing, shall not exceed 0.076 in. in thickness.] *Soft rubber backing shall not exceed 0.025 in. in thickness.*

3. *Section 10* (*c*).—Change the minimum requirement of copper for couplings from 82 to 83 per cent.

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[1] 1918 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. H. E. Smith, Chairman, Committee A-2 on Wrought Iron, Box 491, Eleventh Street Station, Washington, D. C.

[2] 1918 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. E. A. Barrier, Chairman, Committee D-11 on Rubber Products, 31 Milk Street, Boston, Mass.

TENTATIVE REVISION
OF
STANDARD SPECIFICATIONS FOR 2½, 3 AND 3½-IN. DOUBLE-JACKETED COTTON RUBBER-LINED FIRE HOSE FOR PUBLIC FIRE DEPARTMENT USE.

(SERIAL DESIGNATION: D 26–18).[1]

In Section 10 (*c*), change the minimum requirement of copper for couplings from 82 to 83 per cent.

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[1] 1918 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. E. A. Barrier, Chairman, Committee D-11 on Rubber Products, 31 Milk Street, Boston, Mass.

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